4. Hydraulic and Constituent Loading

Permitted wastewater land treatment sites are to be managed as agronomic or other treatment units for the efficient treatment and beneficial reuse of nutrients and water while maintaining soil productivity, minimizing nuisances, and protecting beneficial uses of ground and surface water. The *treatment capacity* of a land application site is determined by performing a land limiting constituent (LLC) analysis to determine the wastewater component that requires the most land for treatment. The LLC may be either water (hydraulic loading) or a particular constituent (constituent loading).

The LLC analysis is necessary for evaluating wastewater treatment alternatives that include land treatment:

- Sanitary wastewater commonly contains low concentrations of nitrogen, phosphorus, chemical oxygen demand (COD), and other constituents, such as total dissolved solids (TDS). For these wastewater streams, the amount of wastewater that can be applied to a treatment site is typically limited by the hydraulic loading rate (hydraulically limited), based on crop water requirements.
- With higher strength wastewaters, however, the amount of applied wastewater may be limited by constituent concentrations—the amount of nitrogen, phosphorus, or organics (BOD or COD), for example—in the wastewater stream. This chemical LLC then dictates the amount of wastewater that may be land applied. In these cases, sites typically use supplemental irrigation water to ensure the crop is receiving adequate water for crop productivity.

The following sections provide guidance for determining appropriate growing and non-growing season hydraulic loading rates, and chemical constituent loading rates.

4.1 Hydraulic Loading

Hydraulic loading of wastewater and supplemental irrigation water are fundamental land treatment design and operational parameters. Appropriate hydraulic loading rates, in both the growing and non-growing seasons are of critical importance to minimize adverse environmental impacts from wastewater treatment. Water balance parameters and calculations are discussed in Section 4.1.1.2.3.

A schematic of the hydrologic cycle, showing water movement in and out of the land treatment area, is provided in Figure 4-1.

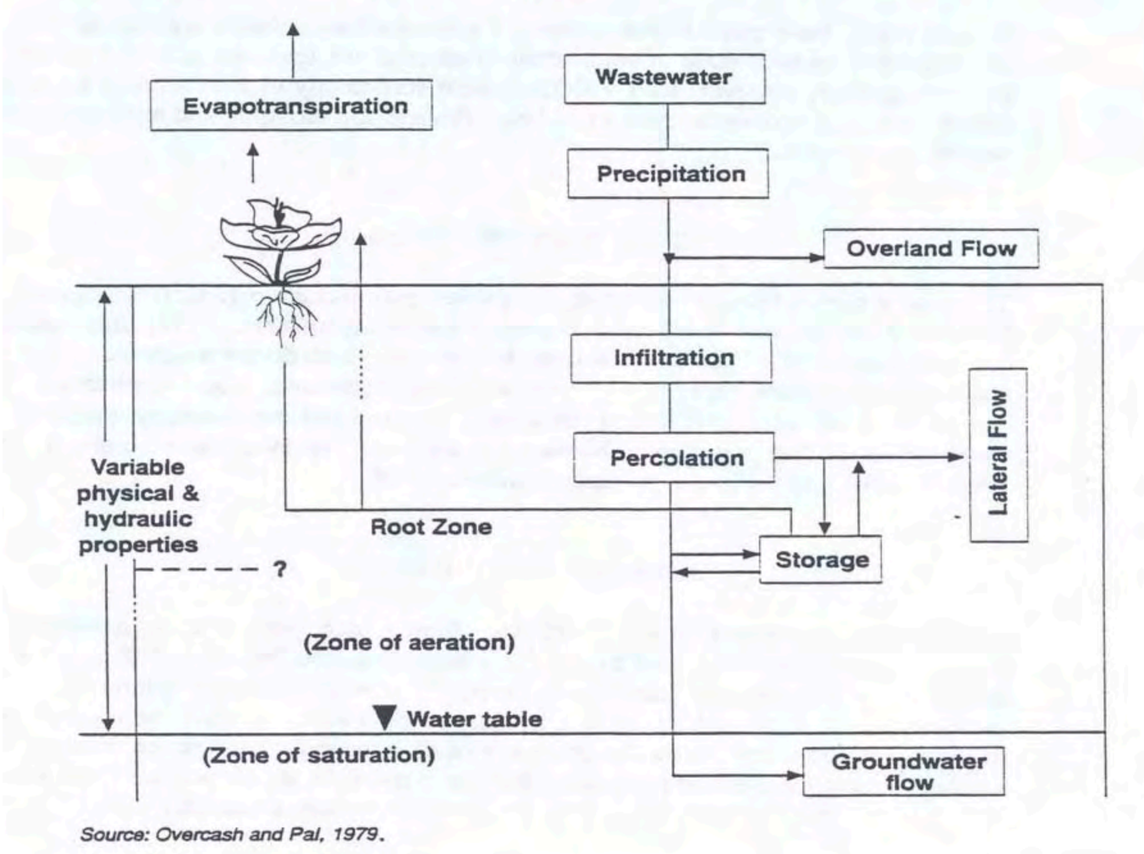

Figure 4-1. Distribution of Wastewater and Precipitation Input to Soil.

An important element of successful wastewater treatment through land-application is the ability of the soil to receive and transmit water. Hydraulic overloading of soil is a common cause of failure of land treatment systems. Uncontaminated overland flow can result in runoff and subsequent surface water contamination problems, as well as wastewater ponding and associated nuisance and vector problems, may result from over-application:

- Many crops are sensitive to poor aeration resulting from hydraulic overloading. Alfalfa, an important crop used at many wastewater land treatment sites, can be harmed or killed by hydraulic overloading.
- Overloading during freezing conditions in winter months can cause excessive ice build-up. Rapid spring thaws can then cause ponding, runoff, or rapid percolation through coarse soils.

Water application rates should not exceed the soil infiltration rate. Soil infiltration capacity should be included in site characterization activities to help determine management requirements, reasonable loading rates, and land area needed. Methods for determining soil hydraulic properties, including soil infiltration rate measurement, are discussed in EPA (1981, Sections 3.3 and 3.4.) NRCS soil surveys provide soil infiltration information, which should be used for preliminary planning only.

Slow-rate land treatment systems generally result in more complete treatment of wastewater than high-rate systems, such as rapid infiltration systems. Slow-rate systems, rather than high rate systems are more appropriate for finer textured soils (silts and clays) with much higher surface areas than high-rate systems. Flow rates through these soil textures are slower, resulting in longer wastewater residence times for biological treatment processes and greater reactive surface areas for physiochemical processes, such as sorption and precipitation, that can effectively treat heavy metals, phosphorus, and certain other constituents.

Rapid infiltration systems can effectively reduce nitrate leaching, and they can effectively filter microorganisms.

The following two sections provide guidance on growing and non-growing season hydraulic loading and on calculating appropriate growing season and non-growing season hydraulic loading rates.

4.1.1 Growing Season Wastewater Land Treatment

Growing season wastewater hydraulic loading rates vary between climatic regions within the state. The following information is provided to assist in the evaluation of wastewater land treatment design during the growing season.

4.1.1.1 Statewide Climatic Regions and Growing Seasons

The length of the growing season is an important criterion when designing a wastewater land treatment system. The growing season is determined by climatic conditions, which vary throughout the state. The *NRCS National Engineering Handbook - Irrigation Guide*, Title 210, Chapter VI, Part 652.0408(c) and (d), September 1997, delineates climatic regions with respect to crops and crop growth (Figure 4-2). Table 4-1 describes each of the climatic regions with respect to location and key parameters for crop growth.

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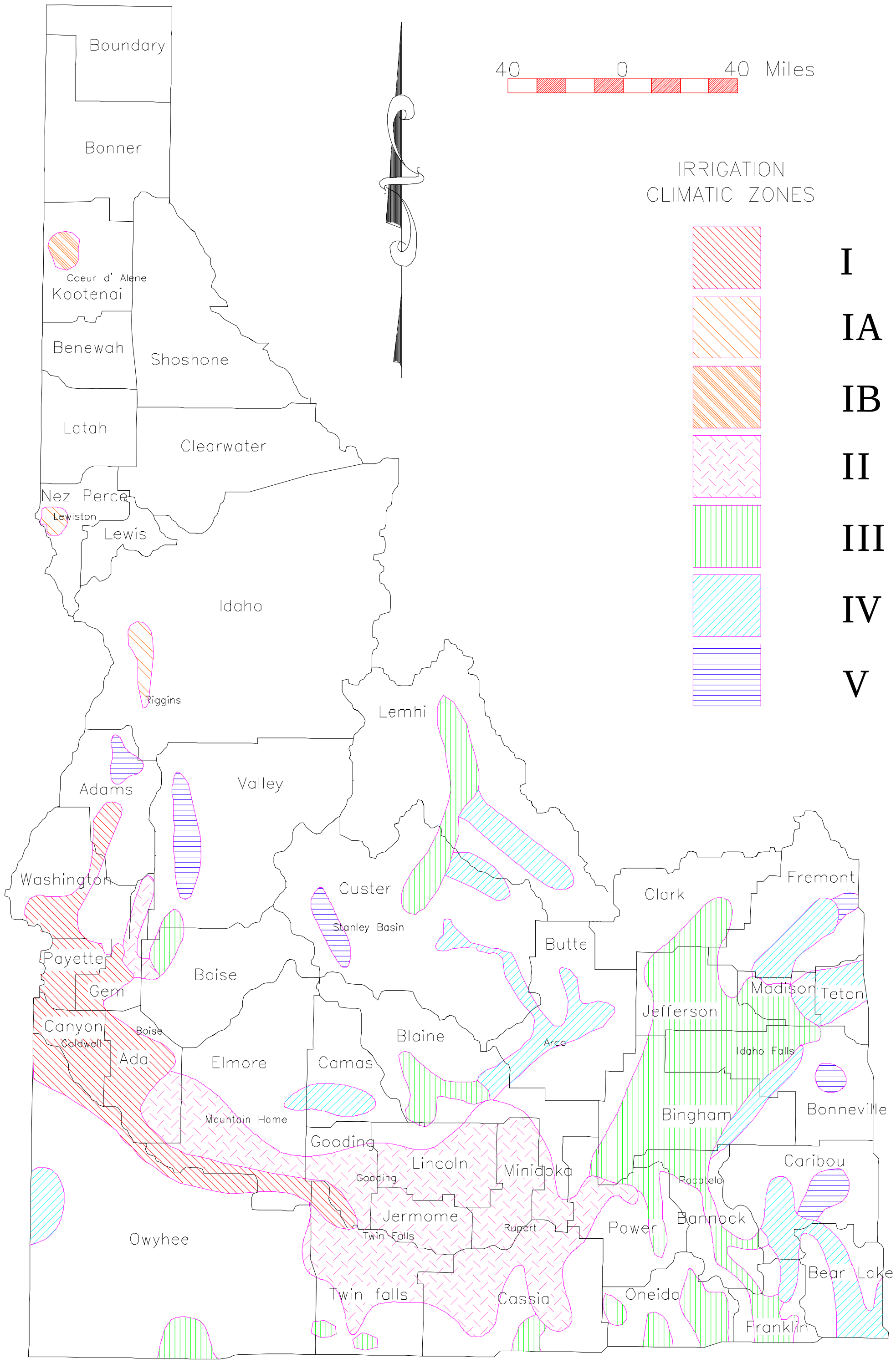

Figure 4-2. Climatic Regions in Idaho (from NRCS National Engineering Handbook - Irrigation Guide).

Table 4-1. General Description of Irrigated Climatic Areas.

Irrigation Climate Area	General Location of Irrigated Climatic Areas	Frost Free Range (days) 32˚-32˚	July *f Factor Range	Representative Station			
				Station Location	Frost-Free Period (days) 32˚	28˚	July *f Factor
I	Lower Snake River from Weiser to Hagerman, except Mt. Home plateau. Weiser, Payette, Boise River Areas.	140 to 160	7.6 to 8.1	Caldwell	147	169	7.7
IA	Riggins, White Bird, and Lewiston	175 to 185	7.5 to 8.5	Lewiston	187	225	8.0
IB	Rathdrum Prairie Area	135 to 155	6.9 to 8.1	Coeur d' Alene	145	179	7.5
II	Snake River Plains from Mt. Home Plateau to American Falls, Including Bliss, Gooding, Shoshone, Oakley, Raft River. Middle Payette, Squaw Creek Area.	120 to 140	7.14 to 7.65	Rupert	132	158	7.46
III	Malad & Bear River Valley to Alexander, Marsh Creek and Portneuf River, Dubois, Snake river from American Falls to Chester and Heise on the South Fork, Challis to Salmon and Lower Lemhi.	100 to 120	6.84 to 7.51	Sugar City	104	128	6.98
IV	Ashton, Upper Lemhi, Pahsimeroi, Arco, Mackay, Howe, Montpelier, Grace	80 to 100	6.53 to 7.09	Arco	82	122	6.89
V	McCall, New Meadows, Stanley Basin, Greys Lake, Green Timber	50 to 80	6.62 to 6.69	McCall	59	100	6.69

*f = monthly consumptive use factor from the formula (USDA, 1993. NEH, Part 623. Appendix A) for determining water requirements for irrigated areas. It is the product of the mean monthly temperature and monthly percent of daylight hours and provides an index of crop consumptive use requirements in different areas.

Additional information regarding crop growing seasons throughout the state is provided in Sections 4.4.1 and 4.4.3. Crop growing season information, which comes from USDA [1993; the NRCS National Engineering Handbook, Part 652.0408(c) and (d)], is not site specific, but is generalized for each region. Reuse permit proposal designs should substantially reflect these general season lengths, with the understanding that site specific information regarding climatic, site, and management differences may be utilized.

Definitions for crop start, crop cover, and crop termination are found at the following Agrimet Web site:

http://www.usbr.gov/pn/agrimet/cropdates.html

Natural Resource Conservation Service general growing season dates for various locations and crops are found in Section 4.4.1.

More detailed information on growing season dates from Agrimet are found in Section 4.4.3, and a description of Agrimet weather stations is found in Section 4.4.2. Agrimet growing season data may also be found on the following Web site:

http://www.usbr.gov/pn/agrimet/id_charts.html

4.1.1.2 Growing Season Hydraulic Loading Rate

During the growing season, timely applications of wastewater and supplemental irrigation water are needed to use the site at an optimum level, with applications scheduled depending on crop water requirements, the strength and volume of wastewater, weather conditions, harvesting periods, and maintenance requirements. As the seasons change, the operator needs to continually evaluate the rates of application and make necessary changes in management.

Irrigation, in slow rate infiltration systems, may need to be discontinued, at times, due to adverse weather, for maintenance purposes, for harvest periods, or for various other reasons. Rest periods are essential for preventing soil clogging and promoting treatment of organic materials in wastewater. It is common to follow a pattern of one day of application followed by a rest period, but actual dose-rest periods are site specific and dependent upon the characteristics of the wastewater and crop requirements. Rest periods can be several days, several weeks, or even months.

Wastewater, however, may not supply enough water for adequate crop production. Hydraulic loading rates will differ for each site, depending on climate and crop selection, and typically include addition of supplemental irrigation water to meet the demands of plant growth. The guidelines that follow provide a means to quantify growing season hydraulic loading rates.

4.1.1.2.1 The Irrigation Water Requirement (IWR)

The irrigation water requirement (IWR) is any combination of wastewater and supplemental irrigation water applied at rates commensurate with the moisture requirements of the crop. A crop should be irrigated throughout the growing season at the IWR:

- Deficit irrigation occurs when a crop is irrigated significantly less than the IWR. Deficit irrigation can increase the salt content of the soil by reducing leaching below the necessary leaching requirement. Deficit irrigation may adversely affect both the health of the crop as well as reduce the yield. Reduced yields mean reduced uptake of applied nutrients, which may otherwise enter groundwater or surface water as contaminants. There are cases where deficit irrigation may be practiced without adverse effects. For example, limited volumes of wastewater and irrigation water may be applied, by design, to a hay crop such that only one or two cuttings are obtained. Nutrient balance and necessary salt leaching can be achieved under this limited season cropping plan. After harvest, wastewater application would cease until the next limited cropping season.
- Irrigating above the IWR can adversely affect crop yields (King and Stark, no publication date) and wastes irrigation water and energy if the supply is ground water and is

pumped. Also, irrigating above IWR increases leaching through the root zone and subsequent transport of constituents to ground water.

It is important, therefore, that a permit limit for IWR not be expressed as a 'maximum' hydraulic load, as this would imply that rates lower than the IWR would be acceptable, which would often not be the case.

Figure 4-3 shows an example of wastewater and irrigation water hydraulic loading versus irrigation water requirement. It can be seen that deficit irrigation is occurring during the middle of the growing season, possibly due to inadequate supplemental irrigation water. Excess irrigation can be seen during both fall and spring, possibly due to wastewater generation and land application in excess of crop needs, which are minimal at those times.

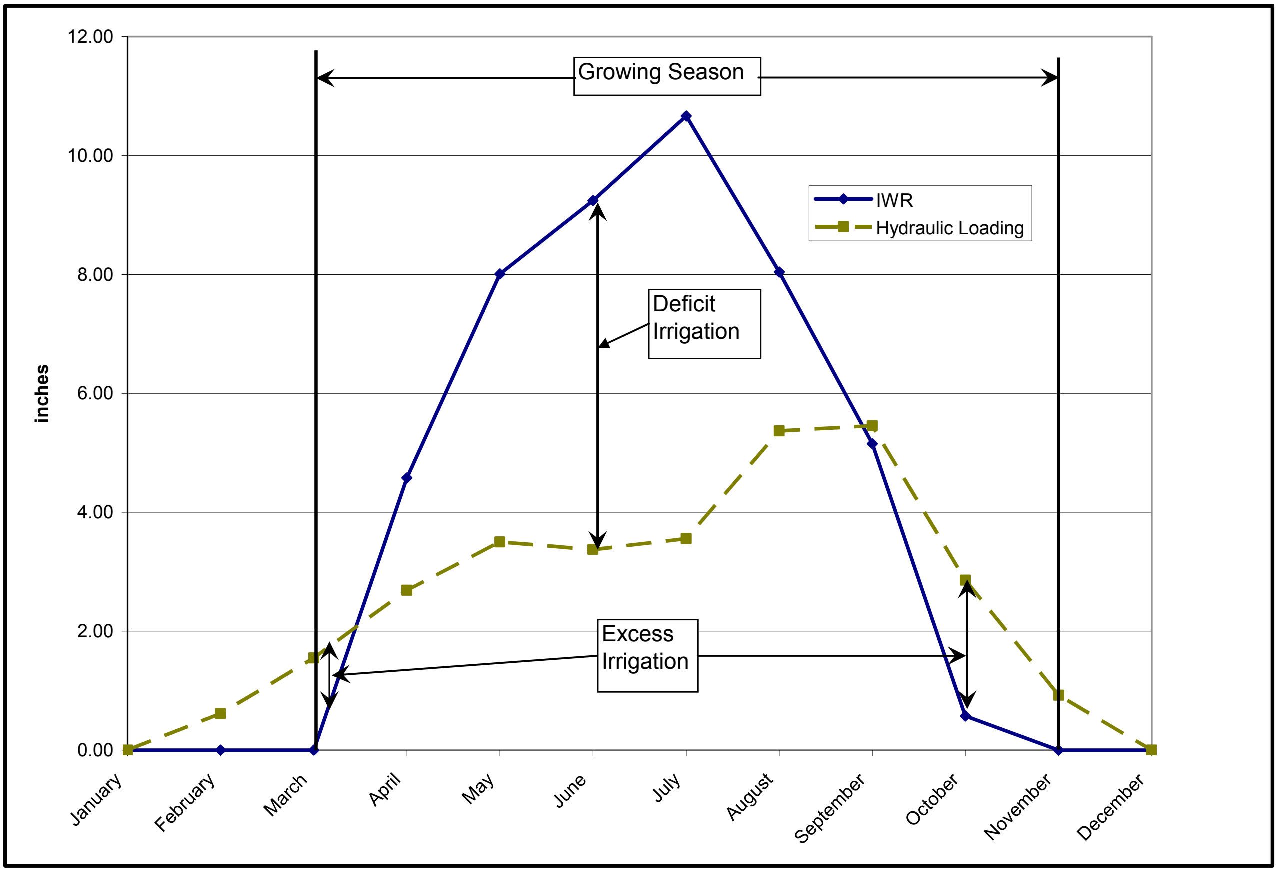

Figure 4-3. Plot of actual wastewater and irrigation water hydraulic loading versus irrigation water requirement showing both deficit and excess irrigation.

Reuse permits should state that growing season hydraulic loading be *substantially* the IWR throughout the growing season – not exactly. Managing an agronomic system is both an art and a science, and it relies very much on the professional judgment of the operator to determine irrigation needs based on weather, daily observation, and previous operations.

The IWR is growing season specific. Utilizing static long term averaged data will necessarily over- or under-estimate the season specific IWR. Planning crop irrigations based upon real-time meteorological data provided by a source, such as USBR Agrimet (Section 4.1.1.2.2), during the growing season is a better option than using static values to determine IWR.

The intent of permit compliance with IWR is to determine whether the permittee is reasonably satisfying crop water requirements. In cases where crop water requirements have been neglected—or where the site did not have an adequate water right to sustain crops—both crop yield and irrigation volumes were dramatically less than what would be expected under typical agronomic management, and demonstrable to be not substantially according to IWR. Given an operating parameter, such as IWR, a somewhat less prescriptive 'limit' is indicated.

4.1.1.2.2 Irrigation Water Requirement Calculations

Both wastewater and supplemental irrigation water should be applied at rates commensurate to the consumptive use requirements of the crop, as these requirements vary during the season. Both EPA (1981, Sections 4.5.1 and 4.5.2) and Crites et al. (2000, Chapter 5) discuss irrigation needs and calculations.

The recommended growing season hydraulic loading rate is the Irrigation Water Requirement (IWR), which can be defined as shown in Equation 4-1 and Equation 4-2:

$$IWR = IR_{net} / E_i$$

Equation 4-1. Calculation of Irrigation Water Requirement (IWR).

Where:

$$IR_{net} = CU - (PPT_e + \text{carryover soil moisture}) + LR$$

Equation 4-2. Calculation of Net Irrigation Requirement (IRnet)

The terms in these equations, in addition to sources of data, are discussed in the following sections.

IR_{net}: Net Irrigation Requirement

IR_{net} is the *net irrigation requirement*—the depth of irrigation water, excluding precipitation, stored soil moisture, and ground water, that is required for crop production and other related uses. (Such related uses may include water required for leaching, frost protection, etc.) The IR_{net} may be obtained or calculated by several means, depending upon objectives. For planning purposes, The monthly IR_{net} (referred to as the *Mean Net Irrigation Requirement*, or Mean IR) may be obtained by crop type for Idaho weather stations from the following Web site:

http://www.kimberly.uidaho.edu/water/appndxet/index.shtml

It should be noted that data compiled and provided at this Web site is for the historical period of record prior to 1983 and does not reflect the historical period of record from 1983 to present.

CU: Crop Consumptive Use

CU is *crop consumptive use* or *crop evapotranspiration* (ET). Either averaged or daily data can be obtained for CU, depending on whether IR_{net} is to be based upon averaged or season-specific data.

The monthly CU (referred to as *Mean Monthly Consumptive Use,* or Mean CU) may be obtained, by crop type, for the pre-1983 historic period of record for Idaho weather stations from the following Web site:

http://www.kimberly.uidaho.edu/water/appndxet/index.shtml.

The U.S. Bureau of Reclamation maintains the Internet-based Agrimet system of weather stations throughout the state of Idaho. Agrimet is a free service that provides users with various reports of daily, monthly and annual ET and other weather data. Annual ET totals and averages for several years 1988 to present by crop and Idaho weather station can be obtained at the following Web site:

http://www.usbr.gov/pn/agrimet/ETtotals.html

Current and historical daily ET data for the growing season for a selected crop, cropping year and weather station (various periods of record) can be obtained at the following Web site:

http://www.usbr.gov/pn/agrimet/etsummary.html

The Idaho Crop Water Use Charts on Agrimet provide a useful resource for irrigation scheduling during the growing season. These charts provide the following for each weather station:

- Crop: Abbreviated identifier for the crop being modeled.
- Start Date: Typically the crop emergence date or beginning of vegetative growth for perennials.
- Daily ET: The previous 4 days of crop specific ET
- Daily Forecast: Average of the last 3 days ET
- Cover Date: Typically when the plant reaches full foliage.
- Term Date: Terminate date (frost, harvest, dormancy, etc.)
- Sum ET: Total crop water use to date by crop, since the start date.
- 7 Day Use: Total crop water use for the last 7 days.
- 14 Day Use: Total crop water use for the last 14 days.

Idaho Crop Water Use Chart data can be obtained from the following Web site:

http://www.usbr.gov/pn/agrimet/id_charts.html

Other sources of ET information (evaporation/evapotranspiration for the non-growing season) are discussed in Section 4.1.2.1.

PPT_e: Effective Precipitation

PPT_e is *effective precipitation* or effective rainfall during the growing period of the crop that can meet the consumptive use requirements of crops.

In Idaho, PPT_e does not generally include such precipitation as is lost to 1) deep percolation below the root zone, 2) surface runoff, or 3) wet canopy and wet soil losses associated with irrigation events. In most areas in Idaho, the difference between PPT (precipitation) and PPT_e is assumed to be from surface evaporative losses rather than percolation and runoff, but this is a general assumption and may not always be valid.

The monthly PPT_e for Idaho weather stations for the pre-1983 historic period of record may be derived from data provided at the following Web site:

http://www.kimberly.uidaho.edu/water/appndxet/index.shtml.

PPT_e from this site is calculated as follows: $PPT_e = CU – IR_{net}$ (note: IR_{net} is Mean IR). To back-calculate monthly PPT for a particular weather station for the historic period of record, divide PPT_e by 0.7 (i.e. it is assumed for these data that the effective precipitation ratio is 0.7, or that PPT_e is 70% of PPT).

Table 4-8 (Section 4.4.5) provides information and equations for making more refined estimates of PPT_e from precipitation (PPT) and consumptive use (CU) data (from USDA, 1993).

It should be noted that the table will yield effective precipitation ratios varying, in some cases significantly, from 0.7. It should also be noted that the time step for calculating PPT_e is monthly.

Daily historical weather data, including daily precipitation, mean daily temperature, etc., for any time period within the historical record for a weather station, can be obtained from the Agrimet Web site below. One can select several meteorological parameters and generate a report.

http://www.usbr.gov/pn/agrimet/webarcread.html

Daily historical archive weather data; including precipitation, ET, mean temperature, etc.; for select water years at a given weather station can be obtained from the Web site below. Only one parameter can be selected per search.

http://www.usbr.gov/pn/agrimet/yearrpt.html

The National Weather Service has more stations in Idaho and records over a longer history than Agrimet but does not monitor ET (CU). These data should be used to augment Agrimet data, and in some cases to calculate ET using temperature and other meteorological data methods. Daily, monthly and annual precipitation, temperature, snow depths, and freeze probabilities can be obtained for Idaho weather stations from various periods of record: 1948 to present; 1961 to 1990; and 1971 to 2000. Daily precipitation and temperature for periods of record from 1961 to 1990 and from 1971 to 2000 are available from the following Web site.

http://www.wrcc.dri.edu/summary/climsmid.html

See also Sections 4.4.4 and 4.4.6 for both mean monthly precipitation and temperature data for the period of record 1971-2000, from Desert Research Institute website:

http://www.wrcc.dri.edu/COMPARATIVE.html

LR: Leaching Requirement

LR is the leaching requirement, defined as the fraction of the irrigation water that must be leached through the crop root zone to control soil salinity at any specified level. It is important to note that a small LR can be satisfied by irrigation inefficiencies (see below) due to incidental losses caused by non-uniformity of water application (Keller-Bliesner, 1990). Leaching requirement and calculations are discussed further in Section 4.4.7.

E_i: Irrigation Efficiency

E_i is the irrigation efficiency, the percentage of applied irrigation water that is stored in the soil and available for consumptive use by the crop. Ranges for irrigation efficiencies are given in Section 4.4.8 (from Ashley et al. 1998). Additional irrigation efficiency information for typical irrigation systems can be found in Neibling (1998) and at the following US Bureau of Reclamation Web site

http://www.usbr.gov/pn/agrimet/irrigation.html#Efficiency)

4.1.1.2.3 Hydraulic Balance Calculations to Determine Percolate Volume

It is often necessary to determine percolate volume of an operating or proposed wastewater land treatment system. Percolate volumes coupled with constituent concentrations, either measured using soil water samplers or estimated from constituent mass balance calculations, give a percolate concentration. Both percolate concentration and volume can then be used in a ground water mixing model analysis to predict potential impacts of wastewater land application to ground water.

Table 4-2 shows a methodology for calculating leaching losses during both the growing and non-growing seasons. More sophisticated methods involve making the time step shorter. Instead of an annual calculation, it can be done month by month, week-by-week etc.

Table 4-2. Calculating leaching losses.

Estimating Leaching Losses During the Growing Season **Given:**	**Example #1: Wheel Line**	**Example #2: Pivot**	**Units**
1) Soil AWC (to 60 inches or root limiting layer)	7.2	7.2	inches
2) Proportion of Soil AWC filled with water at the Start of the Growing Season	0.95	0.95	inches
3) Soil Water at the Start of the Growing Season [(1)*(2)]	6.84	6.84	inches
4) Soil Carryover Water Used in Growing Season [(3) - (1)*0.65] (0.65 is allowable AWC depletion)	2.16	2.16	inches
5) Soil Water Remaining (Soil Water @ Start - Soil Carryover Water Used) (3) - (4)	4.68	4.68	inches
6) Crop Consumptive Use (CU) for entire growing season	33	33	inches
7) Precipitation (PPT) in Growing Season	4.7	4.7	inches
8) Effective Precipitation (PPTe) = 0.7 * PPT or [0.7 * (7)]	0.7 * 4.7 = 3.0	0.7 * 4.7 = 3.0	inches
9) PPT – PPTe (all surface evaporation) (i.e. non-leaching & non-runoff losses) [(7) - (8)]	4.7 - 3.0 = 1.7	4.7 - 3.0 = 1.7	inches
10) Net Irrigation Requirement (IR_{net}) = CU – PPTe - Soil Carryover Water [(6) - (8) - (4)]	33 – 3 – 2.16 = 27.84	33 – 3 – 2.16 = 27.84	inches
11) Irrigation Efficiency (E_i)	0.75	0.85	unitless
12) Irrigation Water Requirement (IWR) = IR_{net} / $E_{i\ [(10)/(11)]}$	27.84 / 0.75 = 37.12	27.84 / 0.85 = 32.75	inches
13) Total Irrigation Losses = IWR - IRnet [(12) - (10)]	37.12 – 27.84 = 9.28	32.75 – 27.84 = 4.91	inches
14) Wind Loss/evaporation of drops in air: Volume of Irrigation Water Applied (V_{ap}) (i.e. IWR) less Volume Irrigation Water 'Caught' (V_c) V_{ap} - V_c = 0.1 * V_{ap} (for Wheel Lines) or Vap - Vc = 0.05 * Vap (for pivots)	0.1 * 37.12 = 3.71	0.05 * 32.75 = 1.64	inches
15) Irrigation Schedule	Weekly Irrigation for 120 days	Bi-Weekly Irrigation for 120 days	
16) Irrigation Events	20	30	events
17) Wet Canopy Losses = 0.1 inch (maximum) per irrigation event [0.1 * (16)]	0.1 * 20 = 2.0	0.1 * 30 = 3.0	inches
18) Excess Water Applied = Total Losses – (Wind Loss + Wet Canopy Losses) [(13) - {(14) + (17)}]	9.28 – (3.71 + 2.0) = 9.28 – 5.71 = 3.57	4.91 – (1.64 + 3.0) = 4.91 – 4.64 = 0.27	inches
19) Residual Water (Excess Water Applied + Soil Water Remaining) [(18) + (5)]	3.57 + 4.68 = 8.25	0.27 + 4.68 = 4.95	inches
20) Water Leached in Growing Season (Amount over Soil AWC) [IF (19) - (1)>0, then((19) - (1), else 0]	8.25 - 7.2 = 1.05	4.95 - 7.2 = negative number so -> 0	inches
21) Soil Water at the End of the Growing Season [IF (20)>0, then (20), else (19)]	7.2	4.95	inches
Estimating Leaching Losses During the Non-Growing Season **Given:**			
22) Soil Water at the Beginning of the Non-Growing Season (same as (21) above)	7.2	4.95	inches
23) Evaporation/Evapotranspiration NGS (ETngs)	4.33	4.33	inches
24) Precipitation (PPT) in Non-Growing Season	3.77	3.77	inches
25) Wastewater Applied (WWapp)	7.5	7.5	inches
26) Net NGS Water Balance (WWapp + PPT - ETngs) [(25) + (24) - (23)]	6.94	6.94	inches
27) Residual Water (Net NGS Water Balance + Soil Water at Beginning of NGS) [(26) + (22)]	14.14	11.89	inches
28) Water Leached in NGS (Amount over Soil AWC) [IF (27) - (1)>0, then (27) - (1), else 0]	6.94	4.69	inches
29) Total Water Leached per Water Year [(20) + (28)]	7.99	4.69	inches
Note: Row 12) can be substituted with water + wastewater applied if substantially different than IWR Note: Row 13) can be substituted with water + wastewater - Irnet			

In Line 18 of Table 4-2, care must be taken in including *wind loss* as a loss of water on the field scale. Most wind loss will reduce ET on other parts of the same field, because the evaporation of the drift loss will cool and humidify the surface air layer in a downwind direction. Therefore, the ET demand downwind is reduced by some amount. This decrease may, from a field scale, offset the drift loss. Of course, if sprinkle irrigation taking place on the edge of a field results in all drift going off site, then this is a loss. Caution should be used not to double count losses.

4.1.2 Non-Growing Season (NGS) Wastewater Land Treatment

The following section includes a general discussion of non-growing season wastewater land treatment, guidelines for non-growing season wastewater land treatment, and criteria for design and operation of wastewater land treatment sites during the non-growing season, including determining non-growing season loading rates.

Some facilities generate and treat wastewater during the non-growing season. Facilities may either discharge to surface water under an NPDES permit issued by EPA, land apply, or store wastewater. Non-growing season loading and storage present economic challenges as land, treatment, and storage costs can be high. If the storage option is utilized, storage ponds must be designed according to the Wastewater Rules (IDAPA 58.01.16) and criteria described in Section 6.3. In addition, plans and specifications must be submitted to DEQ for review and approval.

Factors to be considered in designing non-growing season wastewater land treatment include COD loading, nutrient loading, hydraulic loading, soil, soil-water storage, and climatic conditions.

Excessive non-growing-season wastewater land application may contribute to secondary contamination of the ground water or surface water resource. Excessive COD and/or hydraulic loading coupled with low temperatures limits microbial oxidation and causes accumulation of COD in the soil profile. The rise of soil temperatures during spring thaws with high soil COD levels may cause reducing conditions to develop in the soil. This can cause the reduction of iron and manganese in the soil to mobile forms, which can leach.

Non-growing season-wastewater land application during freezing conditions can cause wastewater to accumulate on the surface of the soil. Accumulated frozen wastewater, with associated chemical constituents, melts during spring thaw conditions and may overload the soils both hydraulically and with respect to constituents such as COD, nitrogen and others. Rapid melting of frozen wastewater may also create the potential for runoff. Wastewater which runs offsite does not undergo land treatment of constituents, and may carry with it sediments which, if these have elevated levels of phosphorus may result in phosphorus contamination of surface water.

Generalized non-growing seasons are found in USDA [1997; NRCS NEH, Part 652.0408(d)] and in Sections 4.4.1 and 4.4.3. Reuse permit proposal designs should substantially reflect these season lengths, with the understanding there may be climatic, site, and management differences not reflected in and which may modify the generalized information.

4.1.2.1 General Guidelines for Non-Growing Season Hydraulic Loading

Non-growing season hydraulic loading should conform to the following guidelines. NGS hydraulic loading:

- will not cause significant degradation to ground water as determined by DEQ;
- will preserve beneficial uses of surface and ground water;
- will not cause prolonged anaerobic conditions to develop in the soil or aquifer, such that the flux of redox sensitive constituents and soluble organics beyond the crop root zone causes significant degradation of ground water;
- will be sufficiently designed so that late winter/early spring thaw or precipitation events do not cause runoff, hydraulic overloading, or other crisis conditions (see further discussion of runoff in Section 4.1.3);
- will not create or contribute to nuisance conditions, crop damage, or adversely affect public health and safety;

4.1.2.2 Design and Operational Guidelines for Wastewater Land Treatment Sites During the Non-Growing Season

Non-growing season criteria for the design and operation of wastewater land treatment sites include the following:

- Wastewater should not be applied when it will freeze and accumulate on the surface of the soil, where ice accumulation on the ground surface is uneven and results in non-uniform hydraulic and constituent loading over the land treatment site.

- The site should be sprinkler irrigated with winterized equipment. Flood or furrow irrigation should not be utilized if they result in prolonged saturated conditions at the head end of the furrow or basin causing both the development of reducing conditions and leaching. Snow and ice in furrows or basins can prevent wastewater from spreading evenly along a furrow or over a flood site. Under certain circumstances, such as small flood basins and operation during winter thaws, flood irrigation can achieve coverage as would be achieved during the growing season.
- Engineering and management controls for the non-growing season should be designed, constructed, maintained, and operated to contain precipitation and applied wastewater so that runoff from the land treatment site is minimized. Ice build-up on fields should be minimized since it may constitute a runoff hazard during winter or spring thaws. See Section 4.1.3 for further guidance on runoff control.
- Wastewater ponding at tail ends of fields should be minimized, and should be pumped back and re-applied or stored in approved storage structures. Acceptable frequency, duration, and volume of ponded water should be determined on a site-specific basis.
- Ground water mixing zone and dispersion modeling for constituents of concern may be necessary to determine impact of leaching and constituent mass loss for proposed non-growing season loading rates. TDS and nitrogen are often constituents of concern. DEQ has developed a NGS ground water impact screening tool which generates a conservative estimate of NGS ground water concentration changes based upon (and designed for) low-strength wastewater loading and site-specific aquifer characteristics. See documentation in Section 4.4.11, and LINK to download the software application.
- A 'minimal leaching' non-growing season hydraulic loading rate (HLL_{ngs}) may be calculated and utilized, according to the methodology provided in Section 4.4.9, as a generally accepted protective approach to non-growing season hydraulic loading

4.1.3 Runoff Control

Engineering and management controls should be designed, constructed, and operated to contain applied wastewater, as well as precipitation and applied irrigation water (if mixed with wastewater) so that runoff from the land treatment site is minimized. It is recommended that regulatory expectations with respect to runoff are design-construct-operate-maintain as opposed to performance based. The reason for this is the fact that there are many meteorological conditions which can complicate compliance determination with a single performance standard.

For example, runoff controls may be designed, and contain, a twenty-five (25) year, twenty-four (24) hour storm event. If, however, this event immediately follows one or more 10 year/24 hour events, or if it occurs on snowpack of significant depth, etc., it would not be reasonable to expect such controls to perform under these circumstances.

4.1.3.1 Runoff Control – Design Considerations and Base Case Scenario

It is recommended that runoff control design be based upon risk of contamination or causation of nuisance to receptors. Receptor risks include:

- proximity to surface waters of the state or irrigation canals, laterals, drains, etc. which may be hydraulically connected to waters of the state;
- proximity to domestic and municipal wells
- proximity to residences, commercial and industrial areas, and other areas of human proximity

Other risk factors include:

- strength of wastewater
- pathogen content of wastewater
- size and wastewater generation capacity of the facility

The *Base Case* for initial design criteria recommended below assumes a proximity to all receptors listed; a high strength wastewater food processing wastewater; and a large (400 MGA) facility. To address surface runoff concerns the following should be applied. Less or more stringent design criteria should be considered depending upon degree of risk less or greater than the base case as defined.

4.1.3.2 Runoff Control Design Criteria and Methodology

The irrigation system should include control structures and management practices that are designed to the following criteria:

- Structures and practices should contain runoff from any site or fields used for wastewater land treatment to property not permitted for land treatment except in the event of a 25 year 24 hour storm event or greater plus snow cover as described below. Whether the area being designed for runoff control is a hydraulic management unit (HMU), or whether the area includes areas between HMUs as well, is to be determined on a site-specific basis depending upon what is reasonable and practical for the specific situation.
- The NRCS TR-55 method should be used for estimating the time of concentration and runoff calculations. If hand calculations for runoff estimation are not desirable, several public domain and commercially-available software programs automate these calculations, including TR-55, available at the NRCS Web site:

  http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-tr55.html

  A Windows-based version of NRCS TR-55 can be downloaded at the following Web site:

  http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-wintr55.html

- The NOAA Atlas 2 precipitation isopluvials should be used for determining the 25 year 24 hour precipitation at the location of the land treatment site. See Section 4.4.12 or the following Web site:

  http://www.wrcc.dri.edu/pcpnfreq/id25y24.gif

- The NRCS Type II rainfall distribution should be applied as the precipitation hyetograph for all land treatment sites in Idaho.
- Provisions should be designed for both the growing season and non-growing season. If a single system is designed for year-round application, the greatest volume of runoff from either the growing season or non-growing season should be used.
- Growing season – For the growing season, the runoff curve number should be based on the hydrologic soil group as determined from the soil types and typical field ground cover (Table 2-2a through 2-2d in the NRCS Technical Reference 55, page 2-5 through 2-8).
- Non-growing season – For the non-growing season, the runoff curve number should be based upon hydrologic soil group D to simulate frozen ground. Also, the greatest monthly average snow depth recorded near the site location with a snow water equivalent of 10% should be used in estimating the runoff contribution from snowmelt. See the Western Regional Climate Center for snow depth data:

http://www.wrcc.dri.edu/htmlfiles/id/id.sd.html

4.2 Wastewater Constituent Loading

As discussed in Section 3, wastewater chemistry and physical characteristics are important factors in the design, operation, and management of wastewater land treatment systems. The following sections discuss constituent loading calculation conventions, and both organic and inorganic constituent loading of wastewater land treatment sites.

4.2.1 Constituent Loading Calculation Conventions for Determining Compliance with Permitted Loading Limits in Wastewater Reuse Permits

Wastewater Reuse Permits specify constituent and hydraulic loading limits. There are various means, which have been employed to calculate loadings which have the potential to yield significantly different results. This has the potential to cause ambiguity in determining permit compliance. Also, the kind of data utilized, as well as the calculation method, have the potential of not being representative, thus calculations of loading rates to the treatment acreage may not be representative. This section addresses these ambiguities by providing guidance on several constituent loading calculation conventions that may be employed in determining compliance with permitted loading limits in Wastewater Reuse Permits. The particular convention employed should be approved by DEQ in advance.

The following sections discuss constituent loading calculations, variable acreage use in hydraulic management units, sampling and analyses, regulatory sampling period (sampling interval), determining appropriate wastewater flows to apply to chemical analytical data for constituent loading calculations, and permit conditions for both constituent loading calculations and determining permit compliance.

4.2.1.1 Constituent Loading Calculations

The following points should be considered when framing permit conditions related to constituent and hydraulic loading rates.

The means of calculating constituent and hydraulic loading rates should be clearly articulated in the permit. Even though multiple legitimate means to calculate loading rates exist, only one method should be allowed in the permit so that no ambiguities arise. The basic equation for the calculation of constituent loading rates is Equation 4-3:

$$M = (Q \cdot C \cdot k)/A$$

Equation 4-3. Calculation of constituent loading rates.

Where:

M = Mass of constituent applied per acre per unit time (e.g. lbs/ac-yr)

Q = Volumetric flow rate per unit time (e.g. MG/yr where MG = million gallons)

C = Constituent concentration (mg/L).

A = Unit area (acres).

k = Unit conversion from mg/L to lb/million gallons (1 mg/L = 8.34 lb/MG).

Example:

$$1500\,\frac{\text{lb}}{\text{ac - mo}} = \frac{7.2\,\frac{\text{MG}}{\text{mo}} * 2500\,\frac{\text{mg}}{\text{L}} * 8.34\,\frac{\frac{\text{lb}}{\text{MG}}}{\frac{\text{mg}}{\text{L}}}}{100\text{ ac}}$$

Or, accounting for all units:

$$1500\,\frac{\text{lb}}{\text{ac} - \text{mo}} = \frac{\frac{7.2\ \text{MG}}{\text{mo}} * \frac{2500\ \text{mg}}{\text{L}} * \frac{1\ \text{kg}}{10^6\,\text{mg}} * \frac{2.2\ \text{lb}}{\text{kg}} * \frac{3.79\ \text{L}}{\text{gal}} * \frac{10^6\,\text{gal}}{\text{MG}}}{100\ \text{ac}}$$

Where:

MG = million gallons	L = liter
mg = milligram	kg = kilogram
mo = month	lb = pound
gal = gallon	ac = acre

Constituent loading calculation results should be reported to the appropriate accuracy according to the rules regarding significant figures found in Section 4.4.13.2.

4.2.1.2 Variable Acreage Use in Hydraulic Management Units

The full acreage of a hydraulic management unit (HMU) should be utilized in loading calculations, only if the full HMU acreage is used. Keep in mind that the HMUs should be designed during permitting to be the fundamental unit used to describe constituent and hydraulic loading. It should also be specified in the permits that facilities utilize the entire acreage of a HMU unless there is a significant, compelling reason not to do so.

If wastewater application is done only to a portion of an HMU, the actual acreage to which wastewater was applied should be used in the loading calculations. Averaging constituent loadings over the entire HMU acreage is not recommended. The location of the partial HMU acreage used in loading calculations should be identified in the annual report. Actual loading and acreage is important for both crop uptake and groundwater contamination considerations. The DEQ electronic data entry spreadsheet *Management Unit Summary* should be modified to include a field to enter actual acres used.

4.2.1.3 Sampling and Analyses

Samples collected for wastewater, irrigation water, or other analyses should be representative of the flow of the monitored stream during the regulatory sampling period specified in the permit.

Permit applications should include a Quality Assurance Project Plan (QAPP) for DEQ review and approval, to be incorporated by reference in the permit, and which specifies:

- location, frequency and type of sampling to be conducted;
- how representative samples will be obtained and how sampling bias will be minimized;
- how additional sampling and analysis (utilizing approved methods, etc.) during the regulatory sampling period may be utilized for constituent loading calculations, in the event the permittee determines this is necessary to better characterize flows under particular circumstances (e.g. clarifier or other unit process upset, etc.).
- quality assurance protocols for analyses utilizing in-house laboratories (address reference samples, duplicates, criteria for determine data quality, actions taken when criteria are not met.

See Section 7.1.6 for further discussion of QAPPs.

All chemical analyses of wastewaters and other waters should be done according to methods approved by DEQ, the U.S. Environmental Protection Agency, or those in a current edition of *Standard Methods for the Examination of Water and Wastewater* (Greenberg et al. 2005). See Section 7 for further information regarding analytical methods.

4.2.1.4 Regulatory Sampling Period (Sampling Interval)

Permits should identify a regulatory sampling period (sampling interval) for each constituent within which a sample is taken. This period would represent an adequate sampling frequency for representative characterization of the media being sampled. Regulatory sampling periods may be hourly, daily, weekly, monthly, quarterly, semi-annually, annually, or once every permit cycle.

Table 4-3 provides examples of regulatory sampling periods.

Table 4-3. Examples of regulatory sampling periods.

Regulatory Sampling Period ->	Daily - 12:00 am to 11:59 pm Note: Many facilities begin their day at the beginning of the morning shift, for example at 8:00 am. The regulatory sampling period can be facility-specific and defined from 8:00 am one day to 7:59 am the next day, or another day.	Weekly - 12:00 am Sunday to 11:59 pm the Following Saturday	Monthly - 12:00 am on the First Day of the Month to 11:59 pm the Last Day of the Month

4.2.1.5 Calculation Methodologies

There are several methods, ranging from simple to complex, which may be used to calculate constituent loading rate from constituent concentration data and flow data. More complex methodologies characterize loading more accurately than simple methods, but involve more sampling and effort in performing calculations. More complex methodologies may be more appropriate in more highly managed wastewater treatment activities, especially where there are closer margins between site loadings and corresponding loading limits. Simpler methods may be more appropriate for sites which are typically loaded substantially less than stipulated loading limits. In this case, the lesser accuracy of simpler methods does not present a great risk in the event simpler methods overestimate loading, since actual loading is substantially less than loading limits. It is important to note that all methods presented may calculate loadings either above or below actual loadings. The error about the value of the actual loading is generally greater with simpler methods and less given more complex methods. A main point of the discussion in this section is to choose an appropriate methodology, and consistently and impartially apply it to avoid perceived or actual irregularities when making loading rate calculations having compliance implications.

Examples in Section 4.4.13.1 illustrate different means to calculate constituent loadings:

- Example 1 illustrates how the constituent loading rate would be calculated from daily flows and a required monthly sample taken in the middle of the month.
- Example 2 is a rigorous method of assigning daily flows to multiple sampling events during a monthly sampling period and illustrates how the constituent loading rate would be calculated
- Example 3 is similar to the method in Example 2 for assigning daily flows to multiple sampling events during a weekly sampling period and illustrates how the constituent loading rate would be calculated.
- Example 4 in is similar to Example 2, but is simpler to calculate, and it is far simpler to write computer code to do the calculation. Yet another method is simply to arithmetically average all concentration data, and then utilize total flow for a given regulatory interval.

The methodology to calculate loading rates for compliance purposes must be specified, either in the facility QAPP incorporated by reference in the permit, or in the permit itself, so that there is no equivocation regarding permit compliance in this area.

4.2.2 Wastewater Constituent Loading Rates

4.2.2.1 Total Suspended Solids (TSS)

Concerns with the land application of wastewaters with high concentrations of suspended solids include: 1) the potential for reducing the infiltration capacity of the soil (clogging the soil) and 2) the potential for damaging the cover crop. See Section 3 for further discussion of suspended solids.

The total suspended solids content of wastewater may include organic or inorganic particulate matter, with most of the organic solids being volatile. Many of the concerns related to the chemical oxygen demand of the wastewater and related problems with loading rates apply to total suspended solids. Loading rates for total suspended solids need to be carefully evaluated. Acceptable loading for total suspended solids can be defined as that rate which does not significantly reduce the infiltration capacity of the soil or damage the cover crop. Application rates should allow for decomposition of the organic material and the necessary dose-rest cycles to assure that potential problems are minimized.

Although organic solids can be almost completely removed by land treatment, problems with odors, ponding, insects and damage to cover crops can develop. Excess solids loadings could result in a solids build-up on top of the soil reducing infiltration rates. To prevent soil clogging, it is necessary to apply wastewater intermittently, allowing drying or resting periods between applications to permit the infiltration rate, which decreases during application, to recover during the drying cycle and for microorganisms to decompose the organic solids. The higher the total suspended solids content of the wastewater, the faster the soil will clog and the more frequently it should be allowed to dry.

The method of wastewater application will, to some extent, determine the amount of solids that can be applied to a field. Generally, spray irrigation is better suited for the application of more solids per acre than flood irrigation, due to the more uniform distribution of solids. However, the nature of the solids and method of distribution will highly influence the rate of application.

4.2.2.2 Chemical Oxygen Demand (COD)

The following section discusses COD assimilative capacity in the soil system, soil chemistry and oxygen demand, and both growing and non-growing season COD loading guidelines for wastewater land treatment sites.

4.2.2.2.1 Soil COD Assimilative Capacity

Soil has long been identified as a good medium for the assimilation of the organic material in wastes. A common measure of organic material is chemical oxygen demand (COD). This is a particularly useful measurement when considering factors influencing the soil chemical environment. The degree of oxygen demand imposed upon the soil system is an important factor in determining to what degree the soil is aerobic or anaerobic, and what chemical processes would be taking place in the system.

The upper limit on the amount of COD that a soil can assimilate depends largely on the environmental conditions and the nature of the waste applied. The major elements that affect the decomposition of organic material applied to the soil are: 1) carbon:nitrogen ratio; 2) oxygen supply; 3) temperature; 4) soil water content; 5) pH; and 6) salinity.

Soil should not be saturated for extended periods in order to keep oxygen levels up. Certain moisture levels are needed for optimum bacterial decomposition. The rate of decomposition increases with increasing temperature, with about 38ºF being very slow and maximum rates occurring around 80ºF. Bacteria, which are the most effective waste decomposers, function best in neutral to slightly alkaline soils with a pH range of 6.5-8.5. High levels of salinity can reduce COD removal by organisms in the soil.

Adding organic materials to soil improves many soil properties, both chemical and physical. In terms of chemical properties, organic materials greatly increase the soil's cation exchange capacity and serve as a reservoir for plant nutrients, particularly nitrogen, phosphorus, and potassium (Bohn et al., 1979). In terms of physical properties, additions of organic materials stimulate microbes to produce polysaccharides and other organic exudates that bind soil particles together into aggregates (Donahue et al., 1977; Lehrsch, 1995) and, ultimately, help to strengthen or stabilize the aggregates so formed (Lehrsch et al., 1994). Stable aggregates resist breakdown from freezing (Lehrsch et al., 1991) and from sprinkler droplet impact (Lehrsch et al., 2005b) and minimize erosion under both surface and sprinkler irrigation (Lehrsch et al., 2005a). Well-aggregated, stable soil has a wide range of pore sizes that provide adequate aeration, sustain infiltration rates, and keep infiltration capacity relatively high (Lehrsch, 1995).

Soil clogging associated with high COD loadings, can severely limit the function of a site to treat wastewater. The conditions that could cause such a problem should be evaluated in order to understand the capacity of the soil for wastewater treatment. Clogging can result from biochemical reactions, excessive loading of organic and inorganic materials (both dissolved and particulate), accumulation of microbial tissues in soil pore spaces (Lehrsch and Robbins, 1996), excessive hydraulic loading, poorly designed sprinkler systems (Lehrsch and Kincaid, 2006), and impaired physical properties at and below soil surfaces (Lehrsch et al., 2005a; Lehrsch and Robbins, 1996).

Clogging generally occurs in the top few inches of soil. This can be seen as an organic mat that is largely independent of the coarseness of the soil. The continued existence of anaerobic conditions in the soil surface layer can lead to clogging. Anaerobic conditions result in a low rate of biological activity. This can result in sludge accumulation and production of ferrous sulfide.

In most cases, the organic material content of municipal wastewaters will not be the limiting factor in their rates of application. Industrial wastewaters such as from food processing, may, however, have a COD content sufficiently high to become a limiting factor. With the application of high strength wastewaters, oxygen may be quickly depleted. If the soil pores have been clogged by wastes or are waterlogged, the diffusion of air is restricted, the rate of decomposition is lowered and the chemical end products will differ. Some of these by-products cause nuisance odors. Odors can be controlled however by maintaining conditions favorable to aerobic (oxygen present) waste decomposition. Under anoxic (oxygen absent) conditions, some elements within the soil, such as iron and manganese, can be reduced to soluble and mobile forms.

To help maintain aerobic conditions within the soil and to prevent associated problems, the yearly average organic loading rate should not exceed 50 pounds COD per acre per day. These guidelines are based on the application of wastewater all year long. This application rate is most commonly tied to the related nitrogen concentrations. The wastewater application rates can be increased for seasonal (summer) use but should be at or below soil assimilation rates, and at rates to insure ground water protection. Adequate dose-rest cycles will help alleviate soil clogging and eliminate oxygen depletion problems.

A guideline COD loading rate of 50 lb/ac-d (for both the growing and non-growing season) first appeared in the 1988 Wastewater Land Application Guidance, and has been in program guidance since that time. The origin of this rate is derived from Idaho-specific potato processing wastewater land application research of Smith et al. (1978). On page 11 of Smith et al. (1978), the summary section states that from 10 to 85 T/Ha COD was applied to fields without anaerobiosis developing 'near the surface, and therefore organic loading is not a limiting factor'. Table 2 of Smith et al. (1978; page 5) shows annual COD loadings ranging from 10 to 85 T/Ha (i.e. 22 lb/ac-d to 188 lb/ac-d). The median loading is about 28.5 T/Ha, or 63 lb/ac-d which was rounded to 50 lb/ac-d by writers of the 1988 guidance (Hamanishi, 2006).

4.2.2.2.2 Non-Growing Season COD Loading Rate

The COD loading of wastewater land treatment sites during the non-growing season, according to the Guidelines, is to be less than 50 lbs/acre/day based on a non-growing season average. It may be necessary to reduce this rate if the site is flood irrigated.

Justification for proposed COD loading during the non-growing season should be made for loadings near guideline rates. Such justification may reference empirical data (what has worked, or what has not), and/or may involve more theoretical approaches which take into consideration oxygen diffusion rates into soil, re-aeration times, soil porosity, temperature, and irrigation scheduling. See Sections 4.4.15 below for further discussion.

4.2.2.2.3 Growing Season COD Loading Rate

COD loading during the growing season, compared to non-growing season loading, is generally a less constraining design parameter. Nevertheless, justification for loadings in excess of the guideline rate of 50 lb/acre/day (based on a growing season average) should be provided as described in the Non-Growing Season COD Loading Rate section.

Carlisle and Phillips (1976) proposed a methodology for quantifying soil assimilative capacity for organic waste applied to land. This methodology is based upon the rate of oxygen diffusion into a soil to satisfy the oxygen demand imposed upon the soil system by the addition of organic waste. It is assumed that temperature is not a limiting factor, which is reasonable for growing season application. This methodology is described in Section 4.4.15.

4.2.2.3 Nutrients

A nutrient is any substance that promotes growth and can be taken up by plants or organisms. Wastewater generally contains nutrients, such as nitrogen (Section 4.2.2.4), phosphorus (Section 4.2.2.7), potassium, calcium, magnesium, iron, and sulfur. In a land treatment system, wastewater can provide essential nutrients to crops. If present at excessive levels, however, some nutrients can become pollutants.

4.2.2.3.1 Non-growing Season Nutrient Loading Rate (NLR_{ngs})

Nutrient loading of wastewater land treatment sites should be commensurate with crop needs, uptake, and efficiency of crop uptake. Non-growing season applications should be made so that applied nutrients are stored in the soils to be available during the subsequent growing season. Justification for non-growing season nutrient loading should demonstrate leaching of nutrients at rates and amounts which substantially protect beneficial uses of ground water and do not cause significant degradation of ground water or exceedance of ground water quality standards (IDAPA 58.01.11.200).

4.2.2.3.2 Growing Season Nutrient Loading Rate (NLR_{gs})

General rates for nitrogen loading have typically been 150% of crop uptake. This approach does not take into consideration nitrogen resident in the soil profile, or nitrogen needs for a particular yield goal. See Section 4.2.2.4.2 for further discussion of calculating nitrogen loading rates. Needs for other major nutrients such as phosphorus and potassium are addressed in the

University of Idaho crop nutrient guides (see also Section 4.2.2.7 for further discussion of phosphorus loading guidelines). The University of Idaho crop nutrient guides or demonstrated agronomic utilization may also be used to help determine appropriate nitrogen loading rates. Regardless of the approach chosen, nutrient loadings need to result in compliance with the Ground Water Rule (IDAPA 58.01.11). Spring soil testing is generally needed to determine nitrogen and other nutrients resident in the soil at the beginning of the season, in order to calculate how much additional nitrogen or other nutrient should be applied to the management unit. Calculations and methodology to determine both nitrogen and phosphorus loading limit compliance is found in Sections 4.4.14 and 4.4.16. Fall soil testing is useful for evaluating the efficiency of nitrogen removal at the end of the crop growing season.

4.2.2.4 Nitrogen

Nitrogen is an important constituent of wastewater and may be one of the main limiting factors in designing a system for wastewater treatment by land application. Therefore, the site's assimilative capacity for nitrogen is an important part of the design of a land treatment system. Nitrogen removal can be very efficient in the soil crop system.

4.2.2.4.1 Nitrogen in the Land Treatment System

Nitrogen is lost or removed from soil systems through several mechanisms including ammonia volatilization, denitrification, crop uptake and harvest, and leaching (Lehrsch et al., 2001). One of these mechanisms, denitrification, requires anaerobic conditions, yet the soil plant system requires an aerobic environment for proper functioning. While both aerobic and anaerobic conditions can coexist at times in soil profiles, but aerobic conditions generally predominate.

On a land treatment site, efforts must be made to control the leaching and runoff losses of nitrogen. Rapid water movement through the root zone via preferential flow paths or macropores such as earthworm burrows or old root channels, or through the porus matrix of the soil itself, which can occur with excess water application to soils, can increase nitrate levels in ground water (Lehrsch et al., 2005c; Wright et al., 1998). The basic approach to reduce leaching is to have a crop that will retain or use the nitrogen. This will help prevent excess nitrate accumulation and potential leaching problems and subsequent ground water pollution. The basic approach in controlling runoff is to implement best management practices to increase infiltration by, for example, paratilling or to minimize runoff by creating small water-storage basins or reservoirs on the site's surface (Lehrsch et al., 2005a). One should also create berms or dikes around the site to keep applied wastewater in place on the land treatment site. Runoff control engineering criteria are discussed further in Section 4.1.3.

Ammonium (NH_4^+) ions tend to remain in the soil and are held in the soil on clay and organic matter cation exchange sites. Ammonium ions can be utilized by both plants and microorganisms as a nitrogen source. Nitrogen as ammonia (NH_3) may be lost from the system as a gas through volatilization. Nitrite (NO_2^-), a highly mobile anion that can be toxic to higher plants, is an intermediate during the microbial conversion of ammonium to nitrate. Nitrite is seldom found in soil, however, because it is quickly converted to nitrate. NO_3^- is readily used by both plants and microorganisms. This completely soluble, highly mobile anion is of primary interest because of its potential impacts on ground water quality.

A soil's organic nitrogen, generally a much larger pool than the soil's inorganic nitrogen, is bound in carbon containing compounds. Examples of organic forms are nucleic acids, proteins (enzymes) and amino acids. Organic nitrogen is generally not available for direct plant uptake. An aerobic environment, however, allows microorganisms to transform organic nitrogen to NH_4^+ and, ultimately, to NO_3^-.

The nitrogen cycle (Figure 4-4) describes the reactions that nitrogen may undergo.

Nitrogen in wastewater may undergo oxidation-reduction reactions when wastes are added to the soil. These reactions are especially important in the case of nitrogen since it is potentially a serious pollutant in wastewater and its behavior in the soil is highly dependent on its state of oxidation. Organic nitrogen is mineralized to form NH_4^+ or NH_3. In well-aerated soil, NH_4^+/NH_3 is nitrified to NO_2^- and then NO_3^-, with the latter moving with the soil water . Under anaerobic soil conditions NO_3^- will be reduced to atmospheric nitrogen (N_2), nitrous oxide (N_2O), and nitric oxide (NO).. N_2, N_2O, and NO are lost from the system as gases.

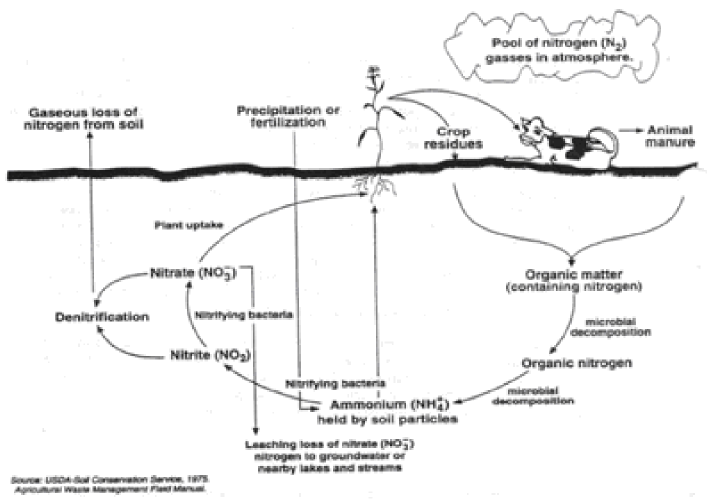

Figure 4-4. General Nitrogen Cycle.

4.2.2.4.2 Nitrogen Loading

The nitrogen loading rates depend upon a number of factors. The main factor is the requirement that the nitrate nitrogen levels of ground water outside the property boundaries of the application system do not exceed either the water quality standard of 10 mg/L NO_3-N, a level of significant degradation as determined by DEQ, or a permit specific level as determined by DEQ. See Section 7.2, *Ground Water Monitoring*, for more information. The previous section describes the different forms of nitrogen and how they are transformed into nitrate. It is therefore important to know the levels of organic nitrogen, ammonium (NH_4^+), and nitrite (NO_2^-) in addition to nitrate. The land treatment system must be operated in a manner that removes nitrogen based on the forms of nitrogen which are known to occur.

To protect ground water quality, keeping in mind that the wastewater application site is for treatment purposes, a design nitrogen application rate should be established. These guidelines recommend that nitrogen loading rates be based on crop uptake efficiency factors (e_f) of 0.60 for annual crops and 0.75 for perennial crops as determined for conditions in the northwest United

States (Henry et al., 1999). Equation 4-4 shows how design nitrogen loading rates are calculated utilizing e_f.

$$N_{required} = \frac{N_{crop}}{e_f}$$

Equation 4-4. Nitrogen loading rates using e_f.

where N_{crop} is the content of nitrogen in both harvested and unharvested above-ground portions of the crop. The excess above N_{crop} is provided for normal losses of applied nitrogen over the needs of the crop by gaseous losses, leaching, and immobilization. Additional irrigation water should be adequate to allow for maximum plant growth and eventual harvest but the amounts of water applied should not be excessive (Lehrsch et al., 2001). It should be noted that factors such as high organic material loading to a land treatment site may, as previously mentioned, lower soil redox, increase denitrification, and consequently lower the uptake efficiency factor (e_f)

Alfalfa presents a unique problem when making required nitrogen calculations since it is able to fix atmospheric nitrogen in addition to its ability to take up plant available nitrogen (nitrate, ammonia) from the soil. It is thought that the proportion of alfalfa nitrogen fixation in a nitrogen adequate environment is 10 to 20 % of N_{crop} (Horneck, 2006), or 20 to 25% of N_{crop} according to Lamb et al. (1995) as cited in Hermanson et al. (no publication date). Therefore, calculations for $N_{required}$ may need adjustment to account for nitrogen fixation. Accounting for nitrogen fixation is particularly important in calculating nitrogen balances for ground water impact modeling. Equation 4-4 can be modified as follows:

$$N_{required} = \frac{\left(1 - N_{fixation}\right) * N_{crop}}{e_f}$$

Equation 4-5. Nitrogen loading rates accounting for nitrogen fixation.

Where $N_{fixation}$ is the proportion of N_{crop} which is fixed from the atmosphere.

Crop testing for nitrate as N should be conducted to determine the potential risk of nitrate poisoning. Table 7-30 in Section 7.7.9.1 gives examples of nitrogen demands and typical crop uptake for selected crops.

4.2.2.5 Salts, Salinity, and Sodium Influences

There are a number of potential problems associated with soluble salts and sodium in certain wastewaters when applied to the soil. This section discusses salts, salinity, and sodium influences from wastewater land application to wastewater land treatment sites.

4.2.2.5.1 Salts

Determining the appropriate salt loading rate for a wastewater land treatment site depends upon allowable impacts to the aquifer, aquifer characteristics, and soil quality for crop health. If there is an adequate supply of good quality, supplemental irrigation water nearby, salts can be managed in the soil profile so as not to accumulate to detrimental levels, even at relatively high salt loading rates. (See Sections 4.2.2.5.2 and 4.2.2.5.3 and Robbins and Gavlak, 1989). Determining appropriate salt loading rates for ground water protection may involve ground water modeling, such as mixing zone modeling. Modeling is usually indicated for sites proposing or having elevated salt loadings. A salt mass balance is calculated along with the hydraulic balance. Predicted salt mass losses and percolate losses are mathematically routed to the aquifer and mixed to obtain a predicted ground water constituent concentration at the down-gradient boundary (See Section 7.7.5.2). Different scenarios of the model can be run, varying salt loading among other parameters, until acceptable predicted ground water impacts are obtained. Salt loading resulting in acceptable predicted impacts would be a first approximation of an appropriate loading rate. Sensitivity analysis, model calibration and validation are also necessary.

Because of the need to protect ground water quality and sustain soil productivity Permitted wastewater land treatment facilities causing significant TDS impacts to ground water, or which pose a risk of causing significant impacts, should develop site specific TDS Management Plans. Plans should include, but not be limited to, the following:

- identification of representative monitoring sites to measure TDS,
- characterization of all known sources of inorganic TDS,
- analysis of alternatives to isolate and reduce TDS being generated or land applied,
- evaluation of the expected improvements to ground water quality, and
- an implementation schedule for TDS reduction

The approach described above is a passive remedial one and may not be appropriate for a facility that has or is currently impacting a ground water supply well. If a public water supply or a private water supply is contaminated by wastewater land treatment activities as described in IDAPA 58.01.11.400, actions on the part of DEQ and/or the facility may be indicated, also as described in Section 400.

4.2.2.5.2 Salinity

High levels of salt in the soil solution may reduce the yield of vegetation or crops grown on the site and adversely impact soil structure which can significantly reduce soil permeability. In most cases salinity will not be a limiting factor. However, considerations should be given to the influence of salt loading to wastewater land treatment sites.

Salinity effects on plants are categorized as: 1) ionic interference; 2) changes in osmotic or diffusion relationships; and 3) toxicity of chemical species. Wastewater high in salts when applied to land can raise the osmotic potential of the soil solution. An excessive rise in the osmotic potential of the soil solution may hinder or prevent plant water uptake. Some of the visible effects of excess salinity are reductions in both total plant size and the growth rate, leaf tip burn, leaf necrosis, and leaf yellowing (Robbins and Gaylak, 1989). Salt-affected plants do not respond to the application of fertilizers because they further increase the osmotic potential of the soil solution and compound the salinity effects.

The salinity of wastewater can be estimated from its electrical conductivity. Electrical conductivity is in turn related to total dissolved solids by the following general equation: TDS (mg/L) = 0.64 * EC (mhos/cm). Each wastewater will have a unique TDS/EC relationship depending upon content of soluble organic or other non-charged species, and type and activity of soluble salts among other factors. It is advisable to irrigate with wastewater, or wastewater/irrigation water mix, which has an electrical conductivity which would not cause foliar burn, plant toxicity, yield decrement etc. USDA Agricultural Handbook No. 60 (U.S. Salinity Laboratory Staff, 1954, Figure 25 and associated text) discusses salinity classifications of irrigation waters and their respective hazards, based upon EC levels. Also shown are classifications of sodium hazards of irrigation waters, based upon SAR levels (see further discussion below). This reference should be consulted when evaluating loading onto wastewater land treatment sites. See the following Web site for further information:

http://www.ars.usda.gov/SP2UserFiles/Place/53102000/hb60_pdf/Hb60ch5.pdf

See also Tanji (1990) for a more recent text.

4.2.2.5.3 Sodium Influences

Sodium (Na^+) is an important constituent of certain wastewaters. When wastewater containing high concentrations of sodium is land-applied, many clay minerals can swell, which hinders or prevents infiltration and reduces water movement through the soil. This tendency occurs when the ratio of sodium to other cations (positively charged ions) is high. This relationship is called the sodium adsorption ratio (SAR) of a wastewater sample or soil extract. The SAR of wastewater should be evaluated frequently, especially when irrigating heavy clay soils.

The importance of Na, calcium (Ca^{2+}), and magnesium (Mg^{2+}) is due to their impact on soil structure, which is a major determinant of water movement and wastewater treatment. Soils with high levels of exchangeable sodium are called sodic soils, and are defined as soils with sodium adsorption ratios (SARs) greater than 15 (Bohn, et al. 1979). To soils with SARs of 10 to 15, one should apply, then incorporate gypsum or calcium chloride or, if the soil contains lime near the surface, elemental sulfur or ferrous sulfate to maintain acceptable soil structure and allow for water infiltration as the SAR is decreased through irrigation and drainage. (Kotuby-Amacher and Koenig, 1999; Robbins and Gavlak, 1989). The relationship between irrigation water salinity and sodium content is critical to crop growth, as shown in Figure 4-5.

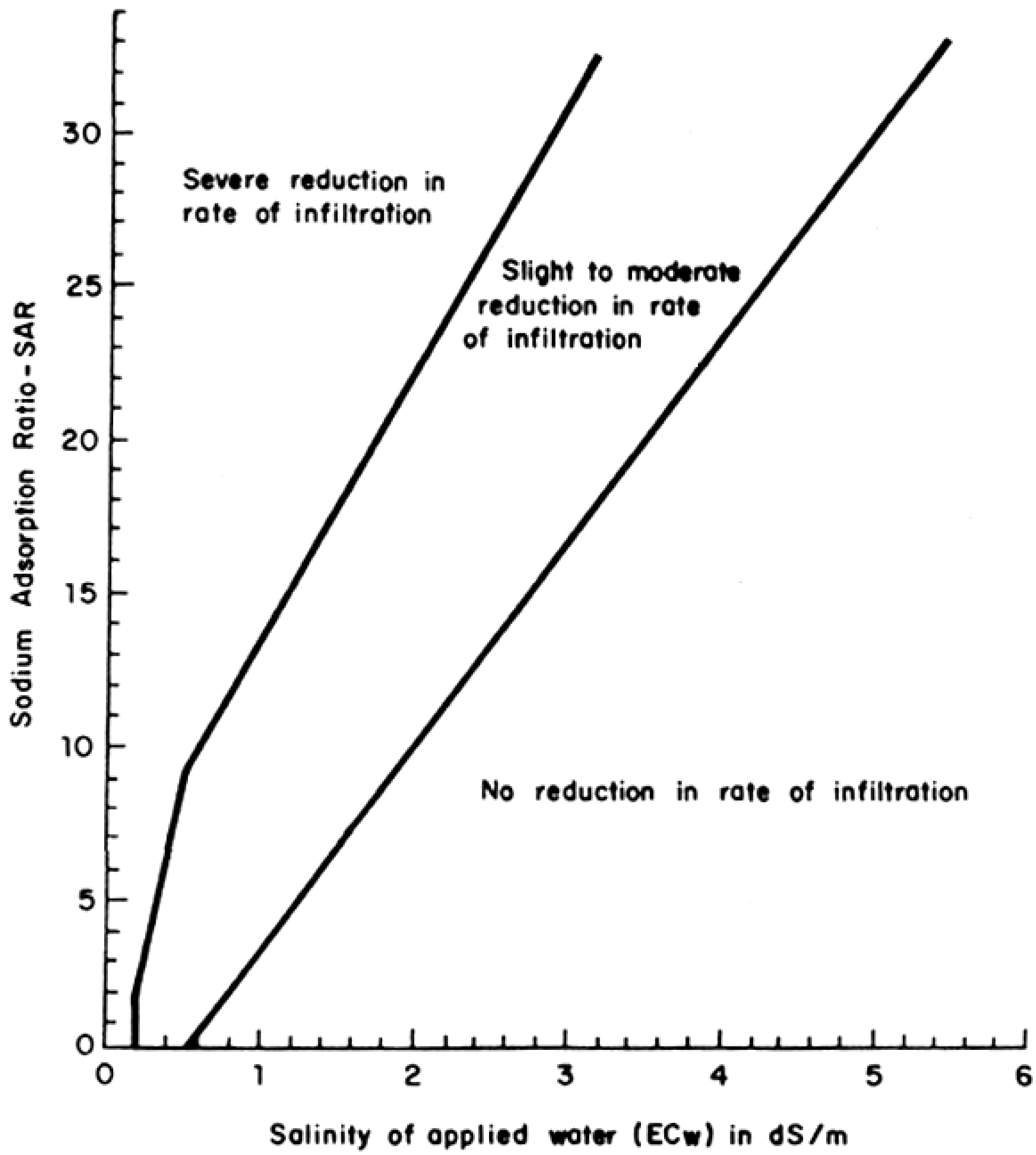

Figure 4-5. SAR as a function of salinity of applied water.

High sodium in wastewater will unfortunately displace calcium and magnesium from the soil's cation exchange sites, leaving high sodium concentrations in the soil. Excessive sodium in soils disperses soil colloids and causes clays to swell. Soil structure collapses and water movement is severely restricted. Decreases in the hydraulic conductivity reduces the water intake and transmission capacity at a site. Such reductions in soil permeability should be avoided.

The degree to which sodium influences soil structure, and thus the degree to which SAR affects infiltration is soil-specific. For example, coarse-textured soils like sands are generally less affected by exchangeable sodium than are fine-textured soils such as clays. Soils containing expanding-type clays, such as montmorillonite, swell and disperse at an increasing rate with increased soil sodium levels.

Since sodium, can cause soil structural problems, the levels of Na, Ca and Mg should be determined in each horizon of the soil profile. An index of sodium influence upon waters, wastewaters, and soils is the sodium adsorption ratio (SAR). The equation for SAR is as follows:

$$SAR = \frac{[Na^{+}]}{\sqrt{\frac{[Ca^{2+}]+[Mg^{2+}]}{2}}}$$

Equation 4-6. Calculation of sodium adsorption ration (SAR).

where Na, Ca, and Mg are measured in milli-equivalents per liter (meq/L) in a soil solution extract or water sample (See Section 7.4.3 for further information). Exchangeable sodium percentage (ESP) is another measure of the Na content, relative to other cations, on soil's cation exchange sites.

4.2.2.6 Heavy Metals

Heavy metals are generally of little concern at wastewater land treatment sites, but there can be facility-specific exceptions. Soils can assimilate heavy metals. Metals are stable and often resist weathering and decomposition. Trace element removal in the soil system is a complex process involving the mechanisms of adsorption, ion exchange, precipitation, and complexation. Adsorption of most trace elements occurs on the surfaces of clay minerals, organic matter, and metal oxides. Cationic species are generally adsorbed, whereas anions tend to be repelled from the clay's negatively charged surfaces. This makes for differences in the rate at which applied anions and cations move through the soil.

Cations in exchangeable forms generally remain in place on the clay's exchange sites until replaced by another cation. The ability of a soil to retain various cations in exchangeable form depends on several factors, with degree of hydration and valence or charge of the cation being among the most important. On the other hand, anions tend to move with water and generally accumulate near the wetting front of water moving as piston-type flow through the soil.

The magnitude of the exchange reactions depends upon the cation exchange capacity (CEC) of the soil which is a function of the type and quantity of clay and organic matter. In general, soils with more clay and organic matter have higher CECs, and have a larger adsorption capacity for trace elements than sandy soils. Such soils have a resulting higher cation retention capacity. Metals are nearly all removed in high CEC soils, which are suitable for slow rate systems. Therefore in many land treatment systems, metal removal will not be a limiting factor. Because of the potential health effects of metals, however, it is necessary to properly manage wastewater application sites to minimize the effects of metals on human health and the environment. Most, but not all, plants generally limit the uptake of metals from the soil. However, metals that accumulate on plant leaves through irrigation enter various food chains, where they become part of the life cycle of soil, plants, animals, and humans, possibly accumulating in animal and human body tissue to toxic levels. This situation is especially critical for humans, who reside at the top of the food chain.

Some metals, then, can be toxic to plants and consumers of plants. Toxicity problems can be reduced by maintaining the soil pH above 6.5. Ceiling concentrations, annual loading levels, and maximum loadings over the life of a land treatment system for several metals (see Tables 1 through 3 – Section 4.4.16) have been prescribed in 40 CFR 503.13 Subpart B: Land Application for land applied sewage sludge.

4.2.2.7 Phosphorus

Phosphorus (P) is a required nutrient for crop growth. It is also a major contributor of pollution to streams, causing algae blooms, low dissolved oxygen, undesirable plant growth, and fish kills. Phosphorus can reach streams by runoff from sites or inflow from aquifers that provide baseflow to streams and rivers. Phosphorus has been implicated in the pollution of surface waters throughout the U.S., including Idaho. Phosphorus leaching from wastewater land treatment sites may present a risk of contamination to surface water depending on site-specific hydrologic conditions. To protect surface waters from the effects of excess phosphorus, surface runoff and deep percolation of phosphorus must be controlled. Surface runoff can contain significant amounts of dissolved and precipitated phosphorus.

Phosphorus applied to the soil surface can be stored in the soil profile by precipitation and adsorption to soil particles. Eventually, with significant phosphorus loading, phosphorus can migrate to lower soil levels and even below the root zone. Once it goes beyond the root zone the phosphorus is unavailable for crop uptake. Soil parent material (which may be coarser textured) and underlying rock in the vadose zone frequently have a lower phosphorus sorption potential than the soil. There is the risk that phosphorus may breakthrough to ground water, which in turn can transport phosphorus from the site to other areas.

The concern for phosphorus contamination of surface water should be addressed in the development of Reuse permits. Applying runoff control technologies to limit surface runoff can prevent or mitigate environmental impacts related to surface runoff. Examples of these practices include applying water or wastewater at a rate less than the infiltration capacity of the soil, uniform sprinkler application, and using berms, ponds, and other runoff control structures. Controlling the application, soil accumulation, and leaching of phosphorus can prevent or mitigate impacts to surface water from ground water interconnections.

4.2.2.7.1 Phosphorus Guidelines

The Wastewater Reuse Permit Program recommends the following process to manage the risk of surface water being impaired by phosphorus applied to land treatment sites. This approach is designed to assure compliance with surface water quality standards for nutrients.

Surface Runoff

Surface runoff concerns should be addressed according to Section 4.1.3. Site closure plans should consider accumulated phosphorus in the surface soils. Soil P upon completion of closure must not pose a threat to surface waters as a result of future irrigation practices or lack of adequate runoff control structures.

Ground Water Interconnection

For sites likely to have a ground water interconnection with surface water, the following approach is suggested:

- Site-specific analysis, information, or other justification may be available that indicates that there is no ground water interconnection and discharge to surface water. In the absence of this information the following goals should be considered for the ground water and the soil when preparing the Reuse permit.
- Ground water concentrations at down-gradient compliance wells should be less than 0.1 mg/L total phosphorus. However, if the ortho P concentration (i.e. concentration of phosphate ion expressed as P) in up gradient ground water is greater than 0.1 mg/L, no increase in phosphorus should be allowed to occur at down gradient compliance wells.
- Achievement of an alternate goal, based on a ground water phosphorus allocation contained in a Total Maximum Daily Load (TMDL), should be attained.
- Plant available soil phosphorus values measured in the 24"-36" soil depth increment should be less than the following.
    - 20 ppm P (by the Olsen method[1]) or 25 ppm (by the Bray method[2]) if ground water is less than 5 feet from the ground surface, or
    - 30 ppm P (the the Olsen method) or 50 ppm (by the Bray method) if ground water is greater than 5 feet from the ground surface
- If phosphorus levels exceed the goals established, then one of the following courses of action should be taken.
    - A permit holder may prepare a site-specific analysis that demonstrates an alternative limit or approach is protective of potentially impacted surface waters. Upon approval by DEQ, this alternate limit or approach may be incorporated into the permit or otherwise used as appropriate.
    - In the absence of any site-specific analysis and alternate limits or approaches approved by DEQ, a permit limitation for phosphorus loading should be considered at 100% of crop uptake.

4.2.2.7.2 Phosphorus Monitoring

Phosphorus, like nitrogen, occurs in several forms in wastewater and is an essential element for biological growth and reproduction. Phosphorus can be present as orthophosphate, polyphosphate, and organic phosphate. These forms are often measured in combination, as total phosphate (total phosphorus) In domestic wastewater, total phosphorus levels generally range

[1] "Olsen method" refers to the Olsen ($NaHCO_3$ extractant) method for determining plant available soil phosphorus. This method is applicable to calcareous soils with >2% $CaCO_3$. See "Methods of Phosphorus Analysis for Soils, Sediments, Residuals, and Waters," Southern Cooperative Series Bulletin No. 396.

[2] "Bray method" refers to the Bray method for determining plant available soil phosphorus. This method is applicable to acid and neutral soils with < 2% $CaCO_3$. See "Methods of Phosphorus Analysis for Soils, Sediments, Residuals, and Waters," Southern Cooperative Series Bulletin No. 396.

from 2 to 20 mg/L, including 1 to 15 mg/L of organic phosphorus and 1 to 15 mg/L of inorganic phosphorus. Total phosphorus levels in food processing wastewaters are generally higher and vary depending upon wastewater type.

Soil monitoring for plant available phosphorus, using the methods described in Section 4.2.2.7.1, appropriate for the soil type may be required. Soil sampling frequency and depth intervals to be sampled should be specified by DEQ in the Reuse permit.

Ground water monitoring for ortho phosphorus will normally be required. Frequency and locations for monitoring should be specified by DEQ in the Reuse permit. Calculations and methodology to determine phosphorus loading limit compliance is found in Section 4.4.16.

4.2.2.8 Hazardous Wastes

Land application of wastewaters containing hazardous wastes will not be allowed unless the type, concentration and amount can be identified and determined that it is not regulated as hazardous waste, and will not adversely affect the beneficial uses of waters of the State or public health. . In situations where the nature of the wastewater is such that it is not regulated by the regulations discussed below, an evaluation of the suitability for treatment by land application will be made by the Department of Environmental Quality (DEQ) on a case-by-case basis. The key element that determines the feasibility of land application as a wastewater treatment alternative is the ability of the soil crop system to treat, not just dispose, of the wastewater in question.

Wastewater land treatment systems are subject to the Idaho Hazardous Waste Management Act (HWMA) of 1983 and the Rules and Standards for Hazardous Waste IDAPA 58.01.05. The primary purposes of the Federal Resource Conservation and Recovery Act (RCRA) is to provide "cradle to grave" management of hazardous wastes, solid wastes, and regulation of underground storage tanks. Hazardous wastes are subject to regulation in their generation, transport, treatment, storage and disposal under RCRA, Subtitle C. In Idaho, DEQ has primacy to administer the hazardous waste (RCRA) program under the HMWA. Please direct any inquiries regarding hazardous waste management, testing requirements to determine if a waste is hazardous, or any other issues pertainant to hazardous wastes to RCRA/HWMA DEQ personnel.

Underground storage tanks are regulated according to their contents. RCRA, Subtitle C regulates those underground storage tanks that contain hazardous wastes. The 1984 Amendments to RCRA added Subtitle I, which regulates underground storage tanks containing chemical and petroleum products. Contact DEQ with questions regarding underground storage tanks containing hazardous wastes or questions regarding the requirements for underground storage tanks containing chemical or petroleum products.

The Rules Regulating the Disposal of Radioactive Materials not Regulated under the Atomic Energy Act of 1954, as Amended IDAPA 58.01.10 govern disposal of wastes containing radioactive substances.

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1)

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4.4 Supplementary Materials for Hydraulic and Constituent Loading

4.4.1 Cropping Season Table (NRCS Data)

Table 4-4 (USDA - National Resource Conservation Service. National Engineering Handbook - Irrigation Guide, Title 210, Chapter VI, Part 652.0408, September 1997.

Climatic Area	Crop	Growing Season Julian Dates Spring	Fall	Calendar Dates Spring	Fall
I	Alfalfa & Clovers	98	283	8-Apr	10-Oct
I	Alfalfa Grass	74	304	15-Mar	31-Oct
I	Alfalfa Seed	98	196	8-Apr	15-Jul
I	Beans	145	245	25-May	2-Sep
I	Corn, Field (Grain)	125	265	5-May	22-Sep
I	Corn, Field (Silage)	125	259	5-May	16-Sep
I	Corn, Sweet	125	227	5-May	15-Aug
I	Grain, Small Spring	82	196	23-Mar	15-Jul
I	Hops	100	243	10-Apr	31-Aug
I	Melons & Cantaloupes	121	267	1-May	24-Sep
I	Mint	98	235	8-Apr	23-Aug
I	Onions	91	258	1-Apr	15-Sep
I	Orchard (with Clover)	100	304	10-Apr	31-Oct
I	Pasture	74	304	15-Mar	31-Oct
I	Potatoes	141	253	21-May	10-Sep
I	Sugar Beets	100	283	10-Apr	10-Oct
IA	Alfalfa	101	293	11-Apr	20-Oct
IA	Corn, Sweet	122	186	2-May	5-Jul
IA	Cucumbers	130	263	10-May	20-Sep
IA	Grain	100	207	10-Apr	26-Jul
IA	Orchards with cover	101	304	11-Apr	31-Oct
IA	Peppers	125	263	5-May	20-Sep
IA	Squash	121	293	1-May	20-Oct
IA	Tomatoes	121	253	1-May	10-Sep
IB	Alfalfa	105	265	15-Apr	22-Sep
IB	Grain	108	227	18-Apr	15-Aug
IB	Grass Seed, Blue	105	191	15-Apr	10-Jul
II	Alfalfa, Seed & Clovers	115	276	25-Apr	3-Oct
II	Alfalfa Grass	98	298	8-Apr	25-Oct
II	Beans, Dry	143	244	23-May	1-Sep
II	Beans, Pole	161	232	10-Jun	20-Aug
II	Corn, Field	135	266	15-May	23-Sep
II	Corn, Sweet	135	230	15-May	18-Aug
II	Grain	91	220	1-Apr	8-Aug
II	Grass Seed & Gras Pasture	98	298	8-Apr	25-Oct
II	Peas; Dry & Lentils	110	213	20-Apr	1-Aug
II	Peas, Green	110	182	20-Apr	1-Jul
II	Potatoes	136	266	16-May	23-Sep
II	Sugar Beets	100	276	10-Apr	3-Oct

Climatic Area	Crop	Growing Season Julian Dates Spring	Fall	Calendar Dates Spring	Fall
III	Alfalfa, Seed & Clovers	125	263	5-May	20-Sep
III	Alfalfa Grass	110	288	20-Apr	15-Oct
III	Beans, Dry	155	255	4-Jun	12-Sep
III	Beans, Pole	152	227	1-Jun	15-Aug
III	Corn, Field	147	237	27-May	25-Aug
III	Corn, Sweet	100	230	10-Apr	18-Aug
III	Grain	100	230	10-Apr	18-Aug
III	Grass Seed & Gras Pasture	110	288	20-Apr	15-Oct
III	Peas, Dry	121	220	1-May	8-Aug
III	Peas, Green	121	191	1-May	10-Jul
III	Potatoes	125	255	5-May	12-Sep
III	Sugar Beets	100	263	10-Apr	20-Sep
III	Truck "B"	152	263	1-Jun	20-Sep
IV	Alfalfa	128	258	8-May	15-Sep
IV	Alfalfa Grass	121	291	1-May	18-Oct
IV	Grass Pasture & Gras Seed	121	291	1-May	18-Oct
IV	Small Grain	130	232	10-May	20-Aug
IV	Potatoes	152	253	1-Jun	10-Sep
V	Alfalfa	148	251	28-May	8-Sep
V	Alfalfa Grass	129	288	9-May	15-Oct
V	Clovers	148	251	28-May	8-Sep
V	Small Grain	145	244	25-May	1-Sep
V	Grass Pasture & GrassSeed	129	288	9-May	15-Oct
V	Seed Potatoes	152	227	1-Jun	15-Aug
VI	Silage Corn	125	259	5-May	16-Sep
VI	Potatoes	127	258	7-May	15-Sep
VI	Spring Grain	105	235	15-Apr	23-Aug
VI	Winter Grain	74	234	15-Mar	22-Aug
VI	Fruit Trees (w/Cover)	121	288	1-May	15-Oct
VI	Vegetables	145	274	25-May	1-Oct

4.4.2 Agrimet Weather Station Reference Table

Table 4-5. Agrimet weather station reference table.

Pacific Northwest Cooperative Agricultural Network
Agrimet Weather Station Locations

Station ID	Station Name	State	Elevation	Latitude	Longitude	Install Date
CEDC	Cedarville	CA	4600	41 35 07	120 10 17	4/24/1985
ABEI	Aberdeen	ID	4400	42 57 12	112 49 36	3/20/1991
AHTI	Ashton	ID	5300	44 01 30	111 28 00	6/2/1987
BOII	Boise	ID	2720	43 37 15	116 11 10	7/31/1995
FAFI	Fairfield	ID	5038	43 18 30	114 49 30	6/25/1987
FTHI	Fort Hall	ID	4445	43 04 17	112 25 52	4/2/1993
GDVI	Grand View	ID	2580	42 54 45	116 03 22	2/10/1993
GFRI	Glenns Ferry	ID	3025	42 52 00	115 21 25	4/13/1993
KTBI	Kettle Butte	ID	5135	43 32 55	112 19 33	10/1/1996
MALI	Malta	ID	4410	42 26 15	113 24 50	6/2/1983
MNTI	Monteview	ID	4855	44 00 54	112 32 09	10/1/1996
NMPI	Nampa	ID	2634	43 26 30	116 38 13	3/11/1996
PICI	Picabo	ID	4900	43 18 42	114 09 57	4/21/1993
PMAI	Parma	ID	2305	43 48 00	116 56 00	3/28/1986
RPTI	Rupert	ID	4155	42 35 42	113 50 17	3/9/1988
RXGI	Rexburg	ID	4875	43 51 00	111 46 00	6/3/1987
TWFI	Twin Falls (Kimberl	ID	3920	42 32 46	114 20 43	5/4/1990
COVM	Corvallis	MT	3597	46 20 00	114 05 00	4/27/1984
CRSM	Creston	MT	2950	48 11 15	114 07 40	5/4/1988
DRLM	Deer Lodge	MT	4680	46 20 08	112 46 00	6/4/1998
RDBM	Roundbutte	MT	3040	47 32 22	114 16 50	5/23/1989
SIGM	St. Ignatius	MT	2940	47 18 48	114 05 53	3/28/1991
EURN	Eureka	NV	5897	39 41 07	115 58 43	8/8/2001
FALN	Fallon	NV	3965	39 27 29	118 46 37	3/27/2001
ARAO	Aurora	OR	140	45 16 55	122 45 01	10/22/1998
BANO	Bandon	OR	80	43 05 28	124 25 02	5/15/1985
BKVO	Baker Valley	OR	3420	44 52 55	117 57 49	5/11/2001
BRKO	Brookings	OR	80	42 01 48	124 14 27	9/28/1999
CHVO	Christmas Valley	OR	4360	43 14 29	120 43 41	4/22/1985
CRVO	Corvallis	OR	230	44 38 03	123 11 24	2/27/1990
DEFO	Dee Flat	OR	1260	45 34 25	121 38 50	2/21/1990
ECHO	Echo	OR	760	45 42 40	119 21 00	3/24/1988
FOGO	Forest Grove	OR	180	45 33 11	123 05 01	8/29/1991
HERO	Hermiston	OR	550	45 49 16	119 30 44	5/17/1983
HOXO	Hood River	OR	510	45 41 04	121 31 05	5/19/1987
HRFO	Hereford	OR	3600	44 29 17	118 01 12	4/29/1998
HRMO	Hermiston (Harec)	OR	607	45 49 10	119 17 00	7/15/1993
IMBO	Imbler	OR	2750	45 26 00	117 58 00	4/5/1994
KFLO	Klamath Falls	OR	4100	42 09 53	121 45 18	3/31/1999
LAKO	Lakeview	OR	4770	42 07 20	120 31 23	4/19/1988
LORO	Lorella	OR	4160	42 04 40	121 13 27	3/31/2001
MDFO	Medford	OR	1340	42 19 52	122 56 16	5/23/1989
MRSO	Madras	OR	2440	44 40 48	121 08 55	5/2/1984
ONTO	Ontario	OR	2260	43 58 40	117 00 55	4/30/1992
PARO	Parkdale	OR	1480	45 32 40	121 37 00	10/20/1989
PCYO	Prairie City	OR	3752	44 26 27	118 37 40	4/12/1989
PNGO	Pinegrove	OR	620	45 39 00	121 30 20	10/20/1989
POBO	Powell Butte	OR	3200	44 14 54	120 56 59	9/21/1993
WRDO	Worden	OR	4080	42 01 01	121 47 13	4/19/2000
GERW	George	WA	1150	47 02 38	119 38 32	5/15/1986
GOLW	Goldendale	WA	1680	45 48 43	120 49 28	11/27/1991
HRHW	Harrah	WA	850	46 23 05	120 34 28	5/27/1987
LEGW	Legrow	WA	580	46 12 19	118 56 10	7/17/1986
LIDW	Lind	WA	1475	46 52 02	118 44 22	5/18/1983
MASW	Manson	WA	1972	47 55 01	120 07 28	11/9/1993
ODSW	Odessa	WA	1650	47 18 32	118 52 43	4/24/1984
OMAW	Omak	WA	1235	48 24 09	119 34 34	1/25/1989
AFTY	Afton	WY	6210	42 44 00	110 56 09	10/20/1987

4.4.3 Growing Season Data from Agrimet

Table 4-6. Agrimet growing season data.

Group 1 **Crop Dates**

Stations: ARAO BANO BRKO CRVO ECHO FALN FOGO HERO HRMO LEGW MDFO

Crops	Extremely Early			Very Early			Early			Average			Late			Very Late			Extremely Late		
	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T
Alfalfa	2/15	4/20	10/15	2/20	4/20	10/15	2/25	4/25	10/15	3/05	5/05	10/15	3/15	5/10	10/15	3/25	5/15	10/15			
Pasture	2/10	4/10	10/15	2/15	4/10	10/15	2/20	4/15	10/15	3/01	4/25	10/15	3/10	5/01	10/15	3/20	5/05	10/15			
Lawn				2/15	4/10	10/15	2/20	4/05	10/15	3/01	4/15	10/15	3/10	4/20	10/15	3/20	4/25	10/15			
Grass Hay										3/01	5/05	10/30									
Winter Grain	2/01	4/20	7/01	2/10	4/25	7/01	2/15	5/01	7/10	2/25	5/05	7/10	3/05	5/10	7/15	3/15	5/15	7/20			
Spring Grain				3/01	5/20	7/10	3/05	5/25	7/15	3/10	6/01	7/20	3/15	6/05	7/25	3/25	6/10	8/01	4/01	6/15	8/05
Spring Grain 2				3/15	6/01	7/20	3/20	6/05	7/25	3/25	6/10	8/01	4/01	6/15	8/05	4/10	6/20	8/10	4/20	6/15	8/05
Potato Shepody																					
Potato Russet				3/20	6/05	8/10	3/25	6/10	8/15	4/05	6/15	8/20	4/15	6/20	8/25	5/01	6/20	9/01			
Potato Russet 2				4/05	6/15	8/15	4/10	6/20	8/20	4/20	6/25	8/25	5/01	7/01	9/01	5/15	7/01	9/05			
Potato Russet 3				4/20	6/25	8/20	4/25	7/01	8/25	5/05	7/05	9/01	5/15	7/10	9/05	6/01	7/10	9/10			
Dry Beans				4/15	6/05	8/10	4/20	6/10	8/15	4/25	6/15	8/20	5/01	6/20	8/20	5/10	6/25	8/25			
Dry Beans 2				5/05	6/20	8/20	5/10	6/25	8/25	5/15	7/01	9/01	5/20	7/05	8/25	6/01	7/10	9/05	7/01	8/05	9/25
Field Corn				3/25	6/25	8/25	4/01	7/01	9/01	4/10	7/05	9/05	4/20	7/10	9/05	5/01	7/10	9/10			
Field Corn 2				4/10	7/05	9/05	4/15	7/10	9/10	4/25	7/15	9/15	5/05	7/20	9/15	5/15	7/20	9/20	6/01	8/01	9/30
Sweet Corn				3/25	6/25	8/01	4/01	7/01	8/05	4/10	7/05	8/10	4/20	7/10	8/15	5/01	7/10	8/20			
Sweet Corn 2				4/10	7/05	8/10	4/15	7/10	8/15	4/25	7/15	8/20	5/05	7/20	8/25	5/15	7/20	9/01	5/25	7/25	9/10
Sweet Corn 3				4/10	7/05	8/10	4/15	7/10	8/15	4/25	7/15	8/20	5/05	7/20	8/25	6/25	8/30	10/05			
Sugar Beets																					
Onions				3/01	6/15	8/05	3/05	6/20	8/10	3/15	6/25	8/15	3/25	7/01	8/20	4/05	7/05	8/25	4/10	7/10	8/30
Garlic																					
Apples				3/10	5/05	10/01	3/15	5/10	10/05	3/20	5/15	10/05	4/01	5/20	10/05	4/15	5/25	10/10	4/25	6/01	10/10
Pears				3/10	7/01	9/01	3/15	7/05	9/05	3/20	7/10	9/10	4/01	7/15	9/15	4/10	7/20	9/20			
Peaches				3/10	7/01	9/01	3/15	7/05	9/05	3/20	7/10	9/10	4/01	7/15	9/15	4/10	7/20	9/20			
Asparagus				2/25	7/05	9/10	3/01	7/10	9/15	3/05	7/15	9/20	3/15	7/20	9/20	4/01	8/01	9/25	4/10	8/01	9/25
Peas/Lentils							3/25	5/25	6/25	4/10	6/01	7/01	4/15	6/05	7/05						
Peppermint				3/05	5/20	7/15	3/10	5/25	7/20	3/20	6/01	7/25	4/01	6/05	8/01	4/10	6/10	8/05			
New Mint																					
Bluegrass Seed										3/01	5/01	7/05	3/10	5/05	7/10						
Carrot Seed																					
Concord Grape				3/15	6/01	9/05	3/20	6/05	9/10	3/25	6/10	9/10	4/01	6/15	9/15	4/05	6/20	9/20	4/25	7/01	9/20
Wine Grape				3/25	6/05	9/15	4/01	6/10	9/20	4/05	6/15	9/20	4/10	6/20	9/25	4/15	6/25	9/30	5/05	7/10	9/30
Cabbage				4/15	6/20	8/01	4/20	6/25	8/05	5/01	7/05	8/10	5/05	7/10	8/15	5/10	7/15	8/20			
Broccoli				3/10	7/01	8/10	3/15	7/05	8/15	3/20	7/10	8/20	3/25	7/15	8/25	4/01	7/20	9/01			
Cranberries				2/15	4/01	10/10	2/20	4/05	10/15	3/01	4/10	10/15	3/10	4/15	10/15	3/20	4/20	10/15			
Strawberries	2/20	4/15	8/15	2/25	4/20	8/15	3/01	4/25	8/20	3/05	4/25	8/25	3/10	5/01	9/01	3/20	5/10	9/05			
Trailing Berries				3/10	5/15	7/10	3/15	5/20	7/15	3/20	5/25	7/20	3/25	6/01	7/25	4/01	6/05	8/01	4/15	6/05	8/01
Blue Berries				3/10	5/25	8/01	3/15	6/01	8/05	3/20	6/05	8/10	3/25	6/10	8/15	4/01	6/15	8/20			
Rape Seed										3/15	5/20	7/01									
Cherries																					
Poplar																					
Melon										5/10	7/15	8/15									
Easter Lilies										2/01	6/15	10/30									

REVIEW DRAFT

Group 2 **Crop Dates**

Stations: BOII GDVI GERW GFRI HOXO HRHW MASW NMPI OMAW ONTO PMAI

Crops	Extremely Early			Very Early			Early			Average			Late			Very Late			Extremely Late		
	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T
Alfalfa				3/01	5/01	10/10	3/05	5/05	10/10	3/15	5/15	10/10	3/25	5/20	10/10	4/01	5/20	10/10			
Pasture				2/25	4/20	10/10	3/01	4/25	10/10	3/10	5/05	10/10	3/20	5/10	10/10	3/25	5/10	10/10			
Lawn				2/25	4/10	10/15	3/01	4/15	10/10	3/10	4/25	10/10	3/20	5/01	10/10	3/25	5/01	10/10			
Grass Hay										3/10	5/15	10/30	3/20	5/20	10/30						
Winter Grain				2/20	5/05	7/05	2/25	5/10	7/15	3/05	5/15	7/15	3/15	5/25	7/20	3/20	5/25	7/20			
Spring Grain				3/05	6/01	7/15	3/10	6/05	7/20	3/15	6/10	7/25	3/25	6/15	8/01	4/15	6/20	8/05			
Spring Grain 2				3/20	6/10	7/25	3/25	6/15	8/01	4/05	6/20	8/05	4/10	6/25	8/10	4/25	7/01	8/15			
Potato Shepody				4/05	6/01	9/01				5/01	6/10	8/10	5/01	6/10	9/01	5/10	6/15	9/01	5/15	6/25	9/05
Potato Russet				4/05	6/15	9/01	4/10	6/20	9/05	4/20	6/15	9/05	5/01	7/01	9/15	5/15	7/05	9/15	5/25	7/10	9/20
Potato Russet 2				4/20	6/25	9/05	4/25	7/01	9/10	5/05	6/25	9/10	5/15	7/10	9/20	5/25	7/10	9/20	6/01	7/15	9/20
Potato Russet 3				5/05	7/05	9/10	5/10	7/10	9/15	5/20	7/05	9/15	6/01	7/20	9/25						
Dry Beans				5/05	6/15	8/15	5/10	6/20	8/20	5/15	6/25	8/25	5/20	7/05	8/25	5/25	7/10	9/01	6/01	7/15	9/01
Dry Beans 2				5/25	7/01	8/25	6/01	7/05	9/01	6/05	7/10	9/05	6/10	7/15	9/05	6/15	7/20	9/05	6/15	7/20	9/05
Field Corn				4/15	7/05	9/05	4/20	7/10	9/10	5/01	7/15	9/15	5/10	7/20	9/15	5/15	7/20	9/20			
Field Corn 2				5/01	7/15	9/15	5/05	7/20	9/20	5/15	7/25	9/25	5/25	8/01	9/25	6/01	7/25	9/30			
Sweet Corn				4/15	7/05	8/10	4/20	7/10	8/15	5/01	7/15	8/20	5/10	7/20	8/25	5/15	7/20	9/01	5/20	7/20	9/01
Sweet Corn 2				5/01	7/15	8/20	5/05	7/20	8/25	5/15	7/25	9/01	5/25	8/01	9/05	6/01	7/25	9/10			
Sweet Corn 3																					
Sugar Beets				3/15	6/20	9/20	3/20	6/25	9/25	4/10	7/05	9/30	4/20	7/10	9/30	4/25	7/10	10/05			
Sugar Beets 2				4/05	7/05	10/01	4/10	7/10	10/05				4/25	7/10	10/05	5/05	7/15	10/15			
Onions				3/15	7/01	8/10	3/20	7/01	8/15	4/01	7/10	8/20	4/15	7/15	8/25	5/01	7/20	9/01			
Garlic																					
Apples				3/25	5/15	9/25	3/25	5/20	9/30	4/05	5/25	9/30	4/15	6/01	10/05	4/25	6/05	10/05	5/05	6/10	10/05
Pears/Peaches				3/20	7/01	9/05	3/25	7/05	9/10	4/05	7/10	9/10	4/15	7/15	9/15	4/20	7/20	9/20			
Cherries										4/10	6/01	9/20	4/25	6/05	9/20						
Asparagus																					
Peas/Lentils				4/01	6/05	7/10	4/05	6/10	7/15	4/10	6/15	7/20	4/20	6/20	7/25	4/25	6/25	8/01			
Peppermint	3/05	5/25	7/20	3/15	6/01	7/25	3/20	6/05	8/01	4/01	6/10	8/05	4/10	6/15	8/10	4/15	6/20	8/15			
New Mint																					
Bluegrass Seed										3/05	5/05	7/10									
Carrot Seed																					
Concord Grape													4/15	6/10	9/30						
Wine Grape										4/15	6/25	9/20	4/25	6/30	9/25						
Cabbage																					
Broccoli																					
Cranberries																					
Strawberries																					
Trailing Berries																					
Blue Berries																					
Rape Seed																					
Poplar										4/20	5/20	10/10									

Group 3 **Crop Dates**

Stations: EURN GOLW IMBO LIDW MALI MRSO PARO RPTI TWFI

Crops	Extremely Early			Very Early			Early			Average			Late			Very Late			Extremely Late		
	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T
Alfalfa	3/1	5/5	10/10	3/5	5/5	10/10	3/10	5/10	10/10	3/20	5/20	10/10	4/1	5/25	10/10	4/5	5/25	10/10	4/10	5/30	10/10
Pasture				3/1	4/25	10/10	3/5	5/1	10/10	3/15	5/10	10/10	3/25	5/15	10/10	4/1	5/15	10/10	4/5	5/20	10/10
Lawn				3/1	4/15	10/10	3/5	4/20	10/10	3/15	5/1	10/10	3/25	5/5	10/10	4/1	5/5	10/10	4/15	5/5	10/10
Grass Hay							3/5	5/15	10/30	3/15	5/20	10/30	3/25	5/25	10/30						
Winter Grain				2/25	5/10	7/10	3/1	5/15	7/20	3/10	5/25	7/20	3/20	6/5	7/25	3/25	6/5	7/25			
Spring Grain				3/15	6/10	7/20	3/20	6/15	7/25	4/1	6/25	8/1	4/10	7/1	8/5	4/25	6/25	8/10			
Spring Grain 2				4/1	6/20	8/1	4/5	6/25	8/5	4/15	7/5	8/10	4/25	7/10	8/15	5/5	7/5	8/15	5/15	7/10	8/20
Spring Grain 3										5/15	7/10	8/20									
Potato Shepody																					
Potato Russet				4/15	6/25	9/5	4/20	7/1	9/10	5/1	7/5	9/15	5/10	7/10	9/20	5/20	7/15	9/20	5/25	7/20	9/25
Potato Russet 2				5/1	7/5	9/10	5/5	7/10	9/15	5/15	7/15	9/20	5/25	7/20	9/25	6/1	7/25	9/25	6/10	7/25	9/25
Potato Russet 3				5/15	7/15	9/15	5/20	7/20	9/20	6/1	7/25	9/25	6/5	7/25	9/30				6/15	8/1	9/30
Dry Beans				5/15	7/1	8/20	5/20	7/5	8/25	5/25	7/15	9/1	6/1	7/25	9/1	6/5	8/1	9/5	6/15	8/10	9/15
Dry Beans 2				6/5	7/15	9/1	6/10	7/20	9/5	6/15	8/1	9/10	6/20	8/10	9/10	6/20	8/10	9/15			
Field Corn				4/25	7/10	9/10	5/1	7/15	9/15	5/10	7/20	9/15	5/20	7/25	9/20	5/25	8/1	9/25			
Field Corn 2				5/10	7/20	9/20	5/15	7/25	9/25	5/25	8/1	9/25	6/5	8/5	9/30	6/5	8/10	9/30			
Sweet Corn				4/25	7/10	8/15	5/1	7/15	8/20	5/10	7/20	8/25	5/20	7/25	9/1	5/20	8/1	9/5			
Sweet Corn 2				5/10	7/20	8/25	5/15	7/25	9/1	5/25	8/1	9/5	6/5	8/5	9/10	6/10	8/15	9/15			
Sweet Corn 3																					
Sugar Beets				4/5	7/1	9/25	4/10	7/5	9/30	4/20	7/10	10/5	4/25	7/15	10/5	5/1	7/20	10/5	5/15	7/20	10/5
Sugar Beets 2				4/25	7/15	10/5	5/1	7/20	10/10	5/10	7/25	10/10	5/15	8/1	10/10	5/15	8/1	10/10			
Onions																					
Garlic				3/1	6/15	8/5	3/5	6/20	8/10	3/15	6/25	8/15	3/25	7/1	8/20	4/1	7/5	8/20			
Apples				4/5	5/25	9/20	4/10	6/1	9/25	4/30	6/5	9/30	5/1	6/10	9/30	5/10	6/15	10/5			
Pears				4/5	7/15	8/30	4/10	7/10	8/25	4/30	7/20	9/1	5/1	7/25	9/1	5/10	7/30	9/5			
Peaches																					
Asparagus																					
Peas/Lentils				4/1	6/5	7/10	4/5	6/10	7/15	4/10	6/15	7/20	4/20	6/20	7/25	4/25	6/25	8/1	5/5	6/25	8/1
Peppermint				3/25	6/25	8/20	4/1	7/1	8/25	4/10	7/5	8/25	4/20	7/10	9/1	4/25	7/15	9/1	5/10	7/20	9/1
New Mint				4/10	7/5	8/25	4/15	7/10	9/1	4/25	7/15	9/5	5/5	7/20	9/15	5/15	7/25	9/25	5/20	7/20	9/25
Bluegrass Seed				3/1	5/1	7/5	3/5	5/5	7/10	3/15	5/10	7/15	3/25	5/15	7/15	4/1	5/20	7/20	4/15	5/25	7/20
Carrot Seed				4/10	6/15	8/20	4/15	6/20	8/25	4/20	6/25	9/1	4/25	7/5	9/5	5/1	7/10	9/10			
Concord Grape																					
Wine Grape																					
Cabbage																					
Broccoli																					
Cranberries																					
Strawberries																					
Trailing Berries																					
Blue Berries																					
Rape Seed																					
Cherries																					
Poplar						10/1	4/10	5/25	10/15			10/15	4/30	6/5	10/15			10/15			10/15

Group 4 **Crop Dates**

Stations: ABEI FTHI ODSW POBO RDBM SIGM

Crops	Extremely Early			Very Early			Early			Average			Late			Very Late			Extremely Late		
	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T
Alfalfa	3/10	5/15	10/05	3/15	5/15	10/05	3/20	5/20	10/05	4/01	6/01	10/05	4/10	6/05	10/05	4/15	6/10	10/05			
Pasture				3/10	5/05	10/05	3/15	5/10	10/05	3/25	5/20	10/05	4/05	5/25	10/05	4/10	6/01	10/05			
Lawn				3/10	4/25	10/05	3/15	5/01	10/05	3/25	5/10	10/05	4/05	5/15	10/05	4/10	5/20	10/05			
Grass Hay							3/15	5/25	10/25	3/25	6/01	10/25									
Winter Grain	3/01	6/01	7/15	3/05	6/01	7/15	3/10	6/01	7/25	3/20	6/05	7/25	4/01	6/15	8/01	4/05	6/20	8/05	4/10	6/25	8/10
Spring Grain				4/01	6/20	7/25	4/10	6/25	8/01	4/15	7/01	8/05	4/25	7/05	8/10	5/01	7/10	8/15			
Spring Grain 2				4/10	7/01	8/05	4/15	7/05	8/10	5/01	7/10	8/15	5/10	7/15	8/20	5/15	7/20	8/25	5/20	7/20	8/25
Spring Grain 3										5/15	7/20	8/25									
Potato Shepody				4/25	7/01	8/25				5/10	6/25	9/05	5/20	7/05	9/10	5/25	7/10	9/15			
Potato Russet				4/25	7/01	9/10	5/01	7/05	9/15	5/10	7/10	9/20	5/20	7/15	9/25	5/25	7/20	9/30	6/10	7/25	9/30
Potato Russet 2				5/10	7/10	9/15	5/15	7/15	9/20	5/25	7/20	9/25	6/05	7/25	9/30	6/05	7/25	10/05			
Potato Russet 3				5/25	7/20	9/20	6/01	7/25	9/25	6/10	8/01	9/30	6/15	8/01	10/05	6/25	8/01	10/05			
Dry Beans				5/15	7/01	8/20	5/20	7/05	8/25	5/25	7/15	9/01	6/01	7/25	9/01	6/05	8/01	9/05			
Dry Beans 2				6/05	7/15	9/01	6/10	7/20	9/05	6/15	8/01	9/10	6/20	8/10	9/10	6/20	8/10	9/15			
Field Corn				5/05	7/15	9/15	5/10	7/20	9/20	5/20	7/25	9/25	6/01	8/01	9/25	6/05	8/05	9/30			
Field Corn 2				5/20	7/25	9/20	5/25	8/01	9/25	6/05	8/05	9/30	6/15	8/10	10/05	6/15	8/10	10/05			
Sweet Corn																					
Sweet Corn 2																					
Sweet Corn 3																					
Sugar Beets				4/10	7/05	9/25	4/15	7/10	9/30	4/25	7/15	10/05	5/01	7/20	10/05	5/05	7/25	10/10	5/10	7/25	10/10
Sugar Beets 2				5/01	7/20	10/05	5/05	7/25	10/10	5/15	8/01	10/15	5/20	8/01	10/15	5/25	8/01	10/15			
Onions										4/20	7/15	8/25									
Garlic							3/20	6/30	8/20	3/30	7/05	8/25				5/05	7/25	9/01			
Apples																					
Pears																					
Peaches																					
Asparagus																					
Peas/Lentils				4/05	6/10	7/15	4/10	6/15	7/20	4/15	6/20	7/25	4/25	6/25	8/01	5/01	7/01	8/05			
Peppermint				4/25	7/01	9/01				5/01	7/20	9/10	5/15	7/25	9/10	5/25	7/25	9/10			
New Mint													5/15	7/25	9/25	5/20	7/25	9/25			
Bluegrass Seed				3/01	5/05	7/10	3/15	5/10	7/15	3/25	5/20	7/20	4/05	5/25	7/20	4/10	6/01	7/25			
Carrot Seed																					
Concord Grape																					
Wine Grape																					
Cabbage																					
Broccoli																					
Cranberries																					
Strawberries																					
Trailing Berries																					
Blue Berries																					
Rape Seed				3/20	5/25	7/05				4/25	7/01	8/05									
Cherries																					
Poplar							4/25	6/05	10/15												

Group 5 Crop Dates

Stations: CEDC CHVO COVM CRSM KFLO KTBI LORO MNTI WRDO

Crops	Extremely Early			Very Early			Early			Average			Late			Very Late			Extremely Late		
	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T
Alfalfa	3/15	5/30	9/30	3/25	5/25	9/30	4/01	6/01	9/30	4/10	6/10	9/30	4/20	6/15	9/30	4/20	6/15	9/30			
Pasture	3/05	5/20	9/30	3/20	5/15	9/30	3/25	5/20	9/30	4/05	6/01	9/30	4/15	6/05	9/30	4/15	6/05	9/30			
Lawn				3/20	5/05	9/30	3/25	5/10	9/30	4/05	5/20	9/30	4/15	5/25	9/30	4/15	5/25	9/30			
Grass Hay										4/05	6/10	10/20									
Winter Grain				3/15	6/05	7/25	3/20	6/10	8/01	4/01	6/15	8/05	4/10	6/25	8/10						
Spring Grain				4/05	6/25	8/01	4/15	7/01	8/05	4/25	7/05	8/10	5/05	7/10	8/15	5/05	7/10	8/15			
Spring Grain 2				4/20	7/05	8/10	5/01	7/10	8/15	5/10	7/15	8/20	5/15	7/15	8/20	5/15	7/15	8/20			
Spring Grain 3													5/25	7/20	8/25						
Potato Shepody																					
Potato Russet				5/05	7/10	9/15	5/10	7/15	9/20	5/20	7/20	9/25	6/01	7/25	9/30	6/05	8/01	10/05			
Potato Russet 2				5/20	7/20	9/20	5/25	7/25	9/25	6/05	8/01	9/30	6/15	8/05	10/05	6/15	8/10	10/10			
Potato Russet 3							6/10	8/01	9/30												
Dry Beans										6/10	7/20	9/05									
Dry Beans 2																					
Field Corn																					
Field Corn 2																					
Sweet Corn																					
Sweet Corn 2																					
Sweet Corn 3																					
Sugar Beets										5/25	8/01	10/15									
Sugar Beets 2										6/05	8/05	10/15									
Onions										5/01	7/20	9/01	5/05	7/25	9/01	5/10	8/01	9/05			
Garlic										3/25	6/25	8/20									
Apples																					
Pears																					
Peaches																					
Asparagus																					
Peas/Lentils							4/10	6/15	7/20	4/15	6/20	7/25	4/25	6/25	8/01	5/01	7/01	8/05	5/15	7/05	8/10
Peppermint				4/25	7/01	9/01	5/01	7/05	9/05	5/10	7/10	9/05	5/20	7/15	9/10	5/25	7/20	9/15			
Peas / Lentils													5/15	7/05	8/10						
New Mint																					
Bluegrass Seed																					
Carrot Seed																					
Concord Grape																					
Wine Grape																					
Cabbage																					
Broccoli																					
Cranberries																					
Strawberries																					
Trailing Berries																					
Blue Berries																					
Rape Seed				5/01	7/05	8/10				5/15	7/15	8/20									
Cherries																					
Poplar																					

Group 6 Crop Dates

Stations: BKVO HRFO LAKO PCYO RXGI

Crops	Extremely Early			Very Early			Early			Average			Late			Very Late			Extremely Late		
	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T
Alfalfa	3/20	5/20	9/15	4/01	6/01	9/30	4/10	6/05	9/30	4/15	6/15	9/30	4/25	6/20	9/30	5/01	6/20	9/30			
Pasture	3/05	5/10	9/15	3/25	5/20	9/30	4/05	5/25	9/30	4/10	6/05	9/30	4/20	6/10	9/30	5/01	6/10	9/30			
Lawn				4/01	5/10	9/30	4/05	5/15	9/30	4/10	5/25	9/30	4/20	6/01	9/30	5/01	6/01	9/30			
Grass Hay							4/05	6/10	10/20	4/10	6/15	10/20									
Winter Grain				3/20	6/10	8/01	4/01	6/15	8/05	4/05	6/25	8/15	4/20	7/01	8/15	4/20	7/01	8/15			
Spring Grain				4/15	7/05	8/05	4/15	7/10	8/10	5/01	7/15	8/20	5/10	7/20	8/20	5/10	7/20	8/20			
Spring Grain 2				5/01	7/15	8/15	5/01	7/20	8/20	5/15	7/25	8/25	5/20	7/25	8/25	5/20	7/25	8/25			
Spring Grain 3													6/01	8/01	9/01						
Potato Shepody																					
Potato Russet				5/15	7/20	9/20	5/20	7/25	9/25	6/01	8/01	9/30	6/05	8/01	9/30	6/05	8/05	10/05	6/10	8/05	10/05
Potato Russet 2				6/01	8/01	9/25	6/05	8/05	9/30	6/15	8/05	10/05	6/15	8/10	10/05	6/15	8/10	10/10	6/15	8/10	10/10
Potato Russet 3				6/15	8/10	10/01	6/20	8/15	10/05	7/01	8/20	10/10	7/05	8/20	10/10				6/20	8/10	10/10

Group 7 Crop Dates

Stations: AFTY AHTI DRLM FAFI PICI

Crops	Extremely Early			Very Early			Early			Average			Late			Very Late			Extremely Late		
	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T
Alfalfa				4/10	6/05	9/25	4/15	6/10	9/25	4/25	6/20	9/25	5/01	6/25	9/25	5/10	6/25	9/25			
Pasture				4/05	5/25	9/25	4/10	6/01	9/25	4/20	6/10	9/25	4/25	6/15	9/25	5/05	6/15	9/25			
Lawn				4/05	5/15	9/25	4/10	5/20	9/25	4/20	6/01	9/25	4/25	6/05	9/25	4/25	6/05	9/25			
Grass Hay										4/20	6/20	10/15									
Winter Grain				4/01	6/15	7/01	4/05	6/20	8/10	4/15	6/25	8/15	4/25	7/05	8/20	4/25	7/05	8/20			
Spring Grain				4/25	7/15	8/15	5/01	7/20	8/20	5/10	7/25	8/25	5/15	8/01	9/01	5/20	8/01	9/01			
Spring Grain 2				5/10	7/25	8/25	5/15	8/01	9/01	5/25	8/05	9/05	6/01	8/10	9/10	6/10	8/10	9/10			
Spring Grain 3																					
Potato Shepody																					
Potato Russet				5/20	7/20	9/20				6/01	8/01	9/30	6/10	8/05	10/05	6/15	8/10	10/10	6/20	8/15	10/15
Potato Russet 2				6/05	7/01	9/25				6/15	8/10	10/05	6/20	8/10	10/10	6/20	8/15	10/15			
Potato Russet 3																					
Dry Beans																					
Dry Beans 2																					
Field Corn																					
Field Corn 2																					
Sweet Corn																					
Sweet Corn 2																					
Sweet Corn 3																					
Sugar Beets																					
Sugar Beets 2																					
Onions																					
Garlic																					
Apples																					
Pears																					
Peaches																					
Asparagus																					
Peas/Lentils																			5/20	7/10	8/15

Notes: S = crop start date; C = crop cover date; T = crop termination date

See Section 4.4.2, Table 4-5, for Meteorological Station Definitions.

REVIEW DRAFT

4.4.4 Mean Monthly Precipitation in Idaho

Table 4-7, Mean monthly precipitation in Idaho, 1971-2000.

Number	Station Name	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1	ABERDEEN EXPERIMNT STN	0.74	0.72	0.86	0.75	1.12	0.92	0.56	0.53	0.77	0.84	0.73	0.7	9.24
2	AMERICAN FALLS 3 NW	1.1	0.97	1.35	1.2	1.6	0.95	0.61	0.6	0.84	0.95	1.2	1.06	12.43
3	ANDERSON DAM	3.23	2.27	2.09	1.4	1.48	0.88	0.53	0.38	0.87	1.2	2.86	3.17	20.36
4	ARBON 2 NW	1.72	1.51	1.64	1.44	1.95	1.24	0.98	0.94	1	1.11	1.42	1.39	16.34
5	ARCO	0.82	1.05	0.86	0.75	1.32	0.9	0.83	0.78	0.7	0.63	0.8	0.81	10.25
6	ARROWROCK DAM	2.87	2.43	2.01	1.52	1.41	0.95	0.4	0.33	0.85	1.07	2.7	2.96	19.5
7	ASHTON	2.25	1.67	1.6	1.47	2.38	1.64	1.12	1.08	1.18	1.41	2.03	2.25	20.08
8	AVERY RS #2	5.19	3.7	3.34	2.74	3.15	2.3	1.46	1.34	1.99	2.67	4.81	4.85	37.54
9	BAYVIEW MODEL BASIN	2.66	2.32	2.18	1.94	2.37	1.92	1.25	1.19	1.25	1.81	3.13	3.29	25.31
10	BLACKFOOT 1 SE	0.86	0.73	0.89	0.93	1.33	0.87	0.53	0.45	0.7	0.84	0.81	0.75	9.69
11	BLISS 4 NW	1.49	1.12	1.01	0.76	0.8	0.54	0.25	0.27	0.53	0.69	1.43	1.22	10.11
12	BOISE 7 N	2.19	1.94	2.24	1.96	2.03	1.13	0.49	0.45	1.07	1.26	2.21	2.23	19.2
13	BOISE LUCKY PEAK DAM	1.78	1.49	1.71	1.49	1.5	0.93	0.39	0.33	0.82	0.9	1.83	1.79	14.96
14	BOISE AIR TERMINAL	1.39	1.14	1.41	1.27	1.27	0.74	0.39	0.3	0.76	0.76	1.38	1.38	12.19
15	BONNERS FERRY	2.7	1.77	1.49	1.42	1.76	1.62	1.02	1.07	1.16	1.61	3.03	2.91	21.56
16	BROWNLEE DAM	2.1	1.67	1.8	1.55	1.86	1.29	0.58	0.6	0.8	1.04	1.91	2.21	17.41
17	BRUNEAU	0.83	0.59	0.84	0.65	0.8	0.68	0.18	0.19	0.55	0.56	0.91	0.74	7.52
18	BUHL NO 2	1.11	0.68	1	0.85	1.08	0.81	0.27	0.3	0.51	0.69	1	0.87	9.17
19	BURLEY MUNICIPAL AP	1.18	0.83	1.08	0.97	1.28	0.87	0.35	0.41	0.64	0.67	1	1.01	10.29
20	CABINET GORGE	4.06	3.13	2.72	2.19	2.43	2.37	1.31	1.3	1.49	2.28	4.37	4.42	32.07
21	CALDWELL	1.55	1.11	1.29	1.13	1.01	0.67	0.3	0.35	0.59	0.73	1.28	1.39	11.4
22	CAMBRIDGE	2.88	2.68	2.18	1.35	1.52	1.04	0.44	0.46	0.83	1.17	2.75	3.2	20.5
23	CASCADE 1 NW	2.73	2.48	2.2	1.87	1.91	1.65	0.69	0.69	1.04	1.48	2.79	3.06	22.59
24	CASTLEFORD 2 N	1.32	0.87	1.08	0.97	1.36	0.81	0.22	0.34	0.62	0.67	1.1	0.94	10.3

25	CENTERVILLE ARBAUGH RNC	4.1	3.3	2.52	2.24	2.11	1.61	0.79	0.52	1.34	1.62	3.54	3.99	27.68
26	CHALLIS	0.51	0.35	0.58	0.58	1.12	0.99	0.78	0.65	0.64	0.43	0.56	0.53	7.72
27	CHILLY BARTON FLAT	0.31	0.27	0.48	0.6	1.29	1.26	0.92	0.81	0.79	0.59	0.44	0.34	8.1
28	COBALT	1.54	0.98	1.2	1.59	2.02	1.84	1.27	1.22	1.1	1.01	1.48	1.58	16.83
29	COEUR D'ALENE	3.28	2.47	2.34	1.89	2.25	2.06	1.02	1.16	1.12	1.67	3.35	3.46	26.07
30	COTTONWOOD 2 WSW	1.88	1.45	1.71	2.39	2.99	2.39	1.53	1.09	1.25	1.5	2.12	1.77	22.07
31	COUNCIL	3.03	2.88	2.56	1.95	2.05	1.49	0.67	0.58	1.11	1.57	3.28	3.19	24.36
32	CRATERS OF THE MOON	1.76	1.65	1.35	1.12	1.8	1.12	0.81	0.78	0.85	0.93	1.48	1.57	15.22
33	DEER FLAT DAM	1.13	0.93	1.21	1.04	1.05	0.75	0.37	0.35	0.54	0.62	1.05	1.11	10.15
34	DIXIE	3.34	2.68	2.45	2.11	2.26	2.19	1.33	1.23	1.33	1.51	3.19	3.58	27.2
35	DRIGGS	1.3	1.04	1.25	1.33	2.14	1.3	1.28	1.04	1.15	1.23	1.22	1.45	15.73
36	DUBOIS EXPERIMENT STN	0.77	0.71	0.95	1.12	2	1.67	1.07	1.01	1.01	0.84	1.01	0.91	13.07
37	DWORSHAK FISH HATCHERY	2.87	2.45	2.41	2.35	2.53	1.69	1.2	0.92	1.32	1.67	3.24	3.02	25.67
38	ELK CITY 1 NE	3.39	2.51	2.62	2.69	3.26	3.14	1.9	1.45	1.75	2.07	3.22	3.14	31.14
39	ELK RIVER 1 S	4.81	4.13	3.13	2.51	2.98	2.33	1.46	1.1	1.73	2.39	4.56	4.93	36.06
40	EMMETT 2 E	1.72	1.6	1.58	1.21	1.29	0.82	0.3	0.33	0.71	0.87	1.72	1.66	13.81
41	FAIRFIELD RANGER STN	2.22	1.71	1.45	1.05	1.33	0.83	0.6	0.42	0.69	0.82	1.77	1.98	14.87
42	FENN RANGER STN (LOWELL	4.64	3.53	3.71	3.6	3.53	3.14	1.39	1.27	2.16	2.84	4.84	4.21	38.86
43	FORT HALL 1 NNE	0.94	0.91	1.17	1.08	1.63	1	0.68	0.77	0.84	1.06	0.99	0.95	12.02
44	GARDEN VALLEY	3.82	2.77	2.45	1.77	1.74	1.4	0.64	0.49	1.18	1.46	3.44	3.87	25.03
45	GIBBONSVILLE	1.99	1.25	1.12	1.15	1.65	1.66	0.91	0.93	0.88	0.74	1.6	1.82	15.7
46	GLENNS FERRY	1.43	1	1.05	0.62	0.81	0.58	0.28	0.27	0.49	0.71	1.22	1.3	9.76
47	GRACE	1.27	1.12	1.43	1.38	2.18	1.31	1.1	1.22	1.32	1.36	1.14	1.14	15.97
48	GRAND VIEW 4 NW	0.64	0.57	0.79	0.66	0.85	0.66	0.25	0.22	0.59	0.51	0.78	0.59	7.11
49	GRANGEVILLE	1.45	1.3	2.37	2.82	3.63	2.84	1.66	1.16	1.62	1.78	1.81	1.5	23.94
50	GROUSE	1.09	1.14	1.25	0.97	1.58	1.55	1.03	0.87	0.79	0.78	1.04	1.2	13.29
51	HAGERMAN 2 SW	1.31	1	1.09	0.64	0.9	0.68	0.21	0.27	0.39	0.63	1.29	1.37	9.78
52	HAILEY 3 NNW	2.32	1.66	1.3	0.98	1.54	1.03	0.64	0.52	0.76	0.74	1.71	1.97	15.17
53	HAMER 4 NW	0.66	0.51	0.7	0.87	1.52	1.18	0.91	0.76	0.61	0.65	0.74	0.66	9.77

54	HAZELTON	1.41	1.02	1.11	0.8	1.14	0.67	0.21	0.29	0.64	0.72	1.29	1.27	10.57
55	HEADQUARTERS	4.93	3.93	3.4	3.09	3.36	2.59	1.49	1.34	1.78	2.6	5	4.93	38.44
56	HILL CITY 1 W	2.23	1.47	1.25	1	1.16	0.85	0.51	0.33	0.76	0.9	1.63	2.04	14.13
57	HOLLISTER	0.91	0.58	0.89	0.95	1.52	1.12	0.47	0.51	0.78	0.84	0.96	0.81	10.34
58	HOWE	0.49	0.62	0.58	0.6	1.1	1.11	0.74	0.77	0.53	0.56	0.65	0.68	8.43
59	IDAHO CITY	3.44	2.77	2.44	1.87	1.88	1.33	0.67	0.51	1.16	1.45	3.08	3.51	24.11
60	IDAHO FALLS 2 ESE	1.25	1.01	1.33	1.27	2.01	1.18	0.74	0.93	0.94	1.12	1.17	1.26	14.21
61	IDAHO FALLS 16 SE	1.41	1.12	1.48	1.43	2.03	1.2	1.06	0.9	1.13	1.17	1.59	1.35	15.87
62	IDAHO FALLS FANNING AP	0.84	0.8	0.95	0.95	1.58	1.1	0.64	0.73	0.76	0.92	0.92	0.83	11.02
63	IDAHO FALLS 46 W	0.64	0.62	0.69	0.79	1.24	1.08	0.66	0.44	0.73	0.57	0.69	0.67	8.82
64	ISLAND PARK	3.38	2.8	2.51	1.91	2.58	2.32	1.6	1.5	1.59	1.69	2.44	3.33	27.65
65	JEROME	1.4	1.07	1.28	0.86	1.14	0.76	0.22	0.27	0.49	0.77	1.29	1.23	10.78
66	KAMIAH	2.23	1.84	2.61	2.53	2.97	2.15	1.23	1.09	1.43	1.69	2.54	2.07	24.38
67	KELLOGG	3.89	2.96	3.03	2.57	2.79	2.23	1.43	1.38	1.69	2.25	4.24	4.31	32.77
68	KETCHUM RANGER STN	2.25	2.06	1.96	1.23	1.83	1.48	0.86	0.82	1.19	1.13	1.78	2.32	18.91
69	KOOSKIA 5 SSE	1.96	1.58	2.65	2.75	3.92	2.36	0.96	0.88	1.23	2.09	2.58	1.94	24.9
70	KUNA	0.99	0.76	1.15	1.06	1.06	0.74	0.28	0.26	0.55	0.6	1.35	1.14	9.94
71	LEADORE NO 2	0.32	0.21	0.45	0.7	1.38	1.12	1.03	0.82	0.71	0.49	0.38	0.4	8.01
72	LEWISTON AP	1.14	0.95	1.12	1.31	1.56	1.16	0.72	0.75	0.81	0.96	1.21	1.05	12.74
73	LIFTON PUMPING STN	0.81	0.81	0.82	1.07	1.62	0.97	0.89	0.89	1.19	1.17	0.84	0.61	11.69
74	LOWMAN	3.57	3.11	2.5	2.18	2.03	1.5	0.68	0.67	1.25	1.57	3.35	3.67	26.08
75	MACKAY LOST RIVER RS	0.65	0.55	0.8	0.66	1.24	1.3	1.06	0.89	0.71	0.58	0.66	0.67	9.77
76	MALAD CITY AP	1.28	1.1	1.2	1.25	2.01	1.13	1.08	0.95	1.09	1.24	1.03	1.05	14.41
77	MALTA 4 ESE	0.79	0.64	0.98	1.11	1.7	1.18	0.92	0.87	0.88	0.79	0.75	0.65	11.26
78	MALTA AVIATION	0.68	0.48	0.75	0.85	1.43	0.91	0.53	0.75	0.74	0.61	0.55	0.44	8.72
79	MASSACRE ROCKS ST PARK	1.09	0.99	1.3	1.34	1.55	0.92	0.63	0.48	0.77	0.99	1.19	1.06	12.31
80	MAY 2 SSE	0.44	0.3	0.31	0.53	1.32	1.13	0.86	0.69	0.66	0.43	0.63	0.54	7.84
81	MCCALL	3.28	2.92	2.55	2.07	2.35	2.08	1.03	1.05	1.45	1.78	3.2	3.45	27.21
82	MCCAMMON	1.81	1.32	1.78	1.27	2.15	0.95	0.98	1.46	1.02	1.05	1.41	1.75	16.95

83	MIDDLE FORK LODGE	1.69	1.35	1.34	1.51	1.65	1.58	0.95	0.98	1	1.21	1.88	1.74	16.88
84	MINIDOKA DAM	1.02	0.83	1.02	0.92	1.19	0.84	0.32	0.38	0.67	0.71	1.03	0.92	9.85
85	MONTPELIER RANGER STN	1.29	1.23	1.31	1.16	1.7	1.25	0.84	0.88	1.25	1.24	1.16	1.16	14.47
86	MOSCOW U OF I	2.99	2.52	2.57	2.52	2.62	1.87	1.12	1.19	1.28	2.01	3.54	3.14	27.37
87	MOUNTAIN HOME	1.32	0.97	1.19	0.92	0.86	0.59	0.38	0.2	0.68	0.76	1.32	1.38	10.57
88	NAMPA SUGAR FACTORY	1.37	1.14	1.35	1.12	1.22	0.63	0.32	0.24	0.58	0.72	1.28	1.4	11.37
89	NEW MEADOWS RANGER STN	2.88	2.62	2.38	2.05	2.26	1.9	0.9	0.81	1.28	1.54	2.71	3.2	24.53
90	NEZPERCE	1.51	1.33	1.85	2.19	3.01	1.99	1.26	1.11	1.31	1.48	1.94	1.43	20.41
91	OAKLEY	0.82	0.64	1.09	1.11	1.71	1.19	0.78	0.73	0.96	0.8	0.79	0.7	11.32
92	OLA 4 S	2.65	2.34	2.35	1.92	1.47	1.15	0.53	0.5	0.88	1.17	2.92	2.87	20.75
93	OROFINO	2.91	2.66	2.53	2.4	2.59	1.67	1.06	0.88	1.24	1.98	3.38	3.29	26.59
94	PALISADES	2.03	1.59	1.63	1.67	2.63	1.68	1.28	1.52	1.44	1.45	1.78	1.71	20.41
95	PARMA EXPERIMENT STN	1.38	1.01	1.25	0.96	1.13	0.84	0.35	0.41	0.65	0.67	1.23	1.27	11.15
96	PAUL 1 ENE	1.02	0.74	0.97	0.89	1.32	0.87	0.41	0.37	0.65	0.7	1.02	0.92	9.88
97	PAYETTE	1.46	1.24	1.1	0.8	0.97	0.73	0.32	0.32	0.46	0.63	1.43	1.6	11.06
98	PICABO	1.62	1.43	1.32	0.92	1.29	0.92	0.46	0.39	0.7	0.89	1.46	1.51	12.91
99	PIERCE	5.44	4.29	3.92	3.39	3.86	2.86	1.8	1.39	2	2.95	5.29	5.13	42.32
100	POCATELLO RGNL AP	1.14	1.01	1.38	1.18	1.51	0.91	0.7	0.66	0.89	0.97	1.13	1.1	12.58
101	PORTHILL	2.13	1.69	1.52	1.43	1.92	1.85	1.34	1.21	1.24	1.41	2.76	2.41	20.91
102	POTLATCH 3 NNE	2.85	2.7	2.52	2.26	2.69	1.78	1.15	1.13	1.29	1.81	3.25	3.18	26.61
103	POWELL	5.16	3.86	3.2	2.65	2.96	2.82	1.58	1.57	2.15	2.77	4.82	5.35	38.89
104	PRESTON	1.39	1.26	1.47	1.39	2.14	1.2	0.94	1.05	1.31	1.61	1.2	1.33	16.29
105	PRIEST RIVER EXP STN	3.74	3.12	2.72	2.25	2.6	2.24	1.39	1.32	1.43	1.92	4.3	4.39	31.42
106	REXBURG RICKS COLLEGE	1.28	1.02	1.11	1.12	1.9	1.49	0.92	0.72	0.87	1.11	1.22	1.09	13.85
107	REYNOLDS	1.18	0.92	1.11	0.94	1.3	0.99	0.38	0.46	0.61	0.77	1.09	1.15	10.9
108	RICHFIELD	1.62	1.28	1.14	0.73	1.07	0.64	0.37	0.32	0.58	0.72	1.32	1.38	11.17
109	RIGGINS	1.18	1.13	1.71	1.78	2.31	1.8	1.08	0.91	1.08	1.12	1.52	1.29	16.91
110	RUPERT 3 WSW	1.14	0.76	1.1	0.79	1.15	1	0.36	0.35	0.56	0.63	0.99	1.01	9.84
111	SAINT ANTHONY 1 WNW	1.26	0.9	1.1	1.13	2.02	1.52	0.97	0.75	0.92	1	1.32	1.3	14.19

112	SAINT MARIES 1 W	3.91	3.1	2.68	2.28	2.49	1.96	1.28	1.13	1.4	2.02	4.13	4.25	30.63
113	SALMON KSRA	0.68	0.49	0.54	0.79	1.42	1.42	1.03	0.82	0.77	0.65	0.73	0.78	10.12
114	SANDPOINT EXP STATION	3.94	3.47	2.85	2.25	2.75	2.46	1.63	1.43	1.6	2.3	4.75	4.75	34.18
115	SHOSHONE 1 WNW	1.38	1.11	1.26	0.69	0.95	0.59	0.26	0.31	0.57	0.65	1.28	1.2	10.25
116	SHOUP	1.3	1.1	0.88	1.18	1.69	1.64	0.99	0.91	0.96	0.91	1.42	1.48	14.46
117	SILVER CITY 5 W	3.21	2.48	2.62	2.26	2.34	1.37	0.68	0.54	0.88	1.51	2.79	3.03	23.71
118	SODA SPRINGS AP	1.14	1.27	1.42	1.35	2.13	1.36	1.25	1.31	1.07	1.26	1.16	1.03	15.75
119	STANLEY	1.66	1.54	1.19	1.07	1.24	1.2	0.73	0.76	0.88	1.14	1.55	2.03	14.99
120	SWAN FALLS P H	0.83	0.59	0.96	1.01	1.06	0.68	0.29	0.22	0.53	0.53	0.89	0.81	8.4
121	SWAN VALLEY 2 E	1.54	0.97	1.38	1.62	2.75	1.48	1.39	1.34	1.39	1.37	1.53	1.3	18.06
122	TAYLOR RANCH	1.09	0.98	1.09	1.59	2.06	1.84	1.16	1.09	0.81	1.01	1.22	1.03	14.97
123	TETONIA EXPERIMENT STN	2	1.19	1.28	1.36	2.61	1.67	1.29	1.26	1.38	1.43	1.48	1.66	18.61
124	TWIN FALLS KMVT	1.07	0.75	1.03	0.83	1.04	0.77	0.22	0.33	0.45	0.75	1.12	1.06	9.42
125	TWIN FALLS 6 E	1.29	0.93	1.21	0.95	1.4	0.84	0.27	0.38	0.65	0.78	1.17	1.12	10.99
126	WALLACE WOODLAND PARK	5.12	4.1	3.68	2.91	3.01	2.61	1.41	1.37	1.75	2.71	5.3	5.25	39.22
127	WARREN	2.64	2.03	2.42	2.25	2.49	2.48	1.41	1.22	1.41	1.81	2.6	2.65	25.41
128	WEISER	1.42	1.38	1.17	0.97	0.96	0.92	0.34	0.31	0.5	0.63	1.65	1.82	12.07
129	WINCHESTER	1.94	1.69	2.46	2.76	3.18	2.18	1.45	1.24	1.44	1.87	2.51	1.99	24.71
130	YELLOW PINE 7 S	3.22	2.83	2.35	1.95	2.1	1.99	1.13	1.09	1.49	1.81	3.22	3.38	26.56

4.4.5 Calculation of Effective Precipitation

From: USDA *National Resource Conservation Service. National Engineering Handbook - Irrigation Water Requirements*, Title 210, Chapter VI, Part 653.0207e. September 1997.

Table 4-8. Average monthly effective precipitation (PPT_e) as related to mean monthly precipitation and average monthly crop consumptive use[1].

MONTHLY MEAN PRECIPITATION PPT INCHES	AVERAGE MONTHLY CROP CONSUMPTIVE USE, CU, IN INCHES										
	0.00	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.00
	Average Monthly Effective Precipitation, PPTe in Inches										
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.5	0.28	0.30	0.32	0.34	0.36	0.38	0.40	0.42	0.45	0.47	0.50
1.0	0.59	0.63	0.66	0.70	0.74	0.78	0.83	0.88	0.93	0.98	1.00
1.5	0.87	0.93	0.98	1.03	1.09	1.16	1.22	1.29	1.37	1.45	1.50
2.0	1.14	1.21	1.27	1.35	1.43	1.51	1.59	1.69	1.78	1.88	1.99
2.5	1.39	1.47	1.56	1.65	1.74	1.84	1.95	2.06	2.18	2.30	2.44
3.0		1.73	1.83	1.94	2.05	2.17	2.29	2.42	2.56	2.71	2.86
3.5		1.98	2.10	2.22	2.35	2.48	2.62	2.77	2.93	3.10	3.28
4.0		2.23	2.36	2.49	2.63	2.79	2.95	3.12	3.29	3.48	3.68
4.5			2.61	2.76	2.92	3.09	3.26	3.45	3.65	3.86	4.08
5.0			2.86	3.02	3.20	3.38	3.57	3.78	4.00	4.23	4.47
5.5			3.10	3.28	3.47	3.67	3.88	4.10	4.34	4.59	4.85
6.0				3.53	3.74	3.95	4.18	4.42	4.67	4.94	5.23
6.5				3.79	4.00	4.23	4.48	4.73	5.00	5.29	5.60
7.0				4.03	4.26	4.51	4.77	5.04	5.33	5.64	5.96
7.5					4.52	4.78	5.06	5.35	5.65	5.98	6.32
8.0					4.78	5.05	5.34	5.65	5.97	6.32	6.68

1/ The PPTe values in the table are based on 3-inches of useable soil water storage (D). D is estimated to be from 40 to 60 percent of the available water holding capacity in the crop root zone, depending on irrigation management practices used. For other values of useable soil water storage, multiply table entries by the soil water storage factors (SF) shown below which correspond to the useable soil water storage (D).

Useable Soil Water storage	(D)	.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.00
Soil Water Storage Factor	(SF)	.722	.773	.86	.93	.97	1.00	1.02	1.04	1.06	1.07	1.148	1.288	1.518

Note: Average monthly effective precipitation cannot exceed average monthly precipitation or average monthly crop consumptive use. When the application of the above factors results in a value of effective rainfall exceeding either, this value must be reduced to a value equal the lesser of the two.

Effective Precipitation may also be calculated from the following equations:

$$PPTe = SF[(0.70917\ PPT^{(0.82416)} - 0.11556)(10)^{(0.02426\ CU)}]$$

Where $SF = (0.531747 + 0.295164D - 0.057697D^2 + 0.003804D^3)$

REVIEW DRAFT

4.4.6 Mean Monthly Temperatures in Idaho

Table 4-9. Mean monthly temperatures in Idaho (1971-2000).

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1	ABERDEEN EXPERIMENT STN	MAX	31	37.1	47.3	57.9	66.9	76.3	85	85.1	74.7	62	44.2	32.9	58.4
		MEAN	21.4	26.7	35.9	44	52.5	60.6	67.1	65.9	56.2	45.3	32.5	22.6	44.2
		MIN	11.7	16.3	24.5	30.1	38.1	44.8	49.1	46.7	37.7	28.5	20.8	12.2	30
2	AMERICAN FALLS 3 NW	MAX	32.9	39.2	49.7	60.1	68.7	78.2	86.3	85.8	75.4	61.8	44.1	33.8	59.7
		MEAN	25.2	30.5	39.2	47.5	55.4	63.6	70.4	69.7	60.4	49.1	35.7	26.3	47.8
		MIN	17.5	21.8	28.6	34.9	42	48.9	54.5	53.6	45.3	36.4	27.3	18.7	35.8
3	ANDERSON DAM	MAX	35.9	40.3	48.6	59.6	69.4	79.4	89.1	88.5	77.7	64.4	45.6	35.6	61.2
		MEAN	27	30	37.5	46.2	54.9	63.2	71.3	70.8	61.6	50.6	36.4	27.3	48.1
		MIN	18.1	19.7	26.4	32.8	40.3	46.9	53.4	53	45.4	36.7	27.1	18.9	34.9
4	ARBON 2 NW	MAX	30.2	34.9	45.1	56.2	65.8	76	84.9	84.2	74.1	60.4	41.9	31.7	57.1
		MEAN	22.4	26.5	35.1	43.3	51.4	59.8	67	66.4	57.2	46	32.4	23.4	44.2
		MIN	14.6	18.1	25	30.4	36.9	43.6	49.1	48.5	40.3	31.6	22.9	15.1	31.3
5	ARCO	MAX	29.5	35.5	45.7	58.1	67	76.6	84.6	83.2	73.6	61.1	41.9	30.4	57.3
		MEAN	17.2	22.6	33.2	43.5	51.8	60	66.5	65.1	55.8	45.1	29.8	18.3	42.4
		MIN	4.8	9.6	20.7	28.8	36.6	43.4	48.4	47	38	29	17.6	6.2	27.5
6	ARROWROCK DAM	MAX	34.7	41.5	50.9	60.3	69.6	79.4	89.2	89	77.6	63.8	45.3	35.4	61.4
		MEAN	28	33.2	41.1	48.5	56.6	65	73	72.6	62.3	50.8	37.6	28.9	49.8
		MIN	21.3	24.9	31.2	36.7	43.5	50.5	56.8	56.2	46.9	37.8	29.8	22.4	38.2
7	ASHTON	MAX	29.5	34.4	41.9	53.3	64.4	73.6	81.6	82	72.9	60.6	41.8	30.9	55.6
		MEAN	19	23.9	31.5	41.3	50.7	58	63.9	63.2	54.7	44.5	30.4	20	41.8
		MIN	8.5	13.4	21.1	29.3	36.9	42.3	46.2	44.3	36.5	28.3	18.9	9	27.9
8	AVERY RS #2	MAX	32.1	36.7	47.2	58.4	68.2	76	84.5	84.7	73.3	56.2	38.4	31.2	57.2
		MEAN	26.8	30.3	38.1	46.4	54.4	61.4	67.4	67.1	58.3	45.6	33.3	26.9	46.3
		MIN	21.4	23.8	28.9	34.3	40.6	46.7	50.3	49.5	43.2	34.9	28.1	22.5	35.4

REVIEW DRAFT

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
9	BAYVIEW MODEL BASIN	MAX	35.1	39	46.5	56.2	65.6	73.5	80.5	80.1	68.6	55.7	42.4	35.5	56.6
		MEAN	28.5	31.5	36.8	44	52	59.1	64.7	63.9	54.3	43.9	35.3	29.1	45.3
		MIN	21.8	23.9	27	31.8	38.4	44.7	48.9	47.6	39.9	32	28.1	22.7	33.9
10	BLACKFOOT 1 SE	MAX	30.5	37.4	48.7	59	67.8	77.3	85	84.8	74.8	61.9	43.9	32	58.6
		MEAN	22.3	28	37.1	45.2	53.2	61.1	67.5	66.8	57.7	46.8	33.4	23.1	45.2
		MIN	14	18.6	25.5	31.4	38.5	44.9	50	48.7	40.5	31.6	22.9	14.2	31.7
11	BLISS 4 NW	MAX	35.9	43.1	53.7	62.8	71.8	81.6	90.1	89.1	78.8	66.2	48	37.2	63.2
		MEAN	27.2	33	41.1	48.7	56.9	65.4	72.2	70.7	61.5	50.3	37	28.4	49.4
		MIN	18.4	22.8	28.4	34.5	41.9	49.2	54.3	52.3	44.2	34.4	25.9	19.5	35.5
12	BOISE 7 N	MAX	35.6	42	50.2	58.4	67.7	77.8	87.6	86.8	75.4	61.7	45.3	36.2	60.4
		MEAN	28.8	34.1	40.7	47	54.7	63.5	72	71.8	62.2	50.8	37.7	29.3	49.4
		MIN	22	26.2	31.1	35.5	41.7	49.1	56.3	56.8	48.9	39.9	30.1	22.4	38.3
13	BOISE LUCKY PEAK DAM	MAX	38.6	45.4	54.4	62.9	72.1	81.4	90.2	90	79.5	66.8	49.3	39.1	64.1
		MEAN	30.2	35.9	42.8	50	58	65.7	72.9	72.8	63.4	53.1	39.9	30.8	51.3
		MIN	21.7	26.4	31.1	37.1	43.8	49.9	55.6	55.5	47.3	39.3	30.4	22.4	38.4
14	BOISE AIR TERMINAL	MAX	36.7	44.5	53.6	61.7	70.7	80.3	89.2	88	77.2	64.3	47.5	37.2	62.6
		MEAN	30.2	36.7	43.8	50.6	58.6	67.2	74.7	73.9	64.2	52.8	39.9	30.6	51.9
		MIN	23.6	28.8	34	39.4	46.6	54.2	60.3	59.8	51.2	41.3	32.4	24.1	41.3
15	BONNERS FERRY	MAX	33.3	39.2	49.5	60.4	69.3	76	83.1	83.4	72.3	57.4	41.3	33.5	58.2
		MEAN	26.9	31.8	39.3	47.6	55.5	61.8	66.9	66.7	57.1	45.8	35	27.8	46.9
		MIN	20.5	24.3	29.1	34.7	41.6	47.6	50.7	50	41.9	34.1	28.6	22.1	35.4
16	BROWNLEE DAM	MAX	37.7	44.9	55.3	65	74.1	83.5	94.1	93.7	82.1	67.5	49.1	39.3	65.5
		MEAN	30.5	36	44.7	52.9	61.1	69.5	78	77.7	67.4	55	41	32.3	53.8
		MIN	23.3	27	34	40.7	48	55.5	61.9	61.7	52.7	42.4	32.8	25.2	42.1
17	BRUNEAU	MAX	40.2	48.3	58.3	66.7	75.1	84.6	93	92	81.5	68.6	51.1	40	66.6
		MEAN	31.4	37.5	45.1	51.9	59.9	68.1	75.1	73.7	63.8	52.8	40.2	31.1	52.6
		MIN	22.5	26.7	31.9	37.1	44.6	51.6	57.1	55.3	46	37	29.3	22.2	38.4

REVIEW DRAFT

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
18	BUHL NO 2	MAX	33.5	40.1	49.7	58.7	67.1	76.6	85.7	85	74.5	62.2	45.1	34.9	59.4
		MEAN	26.3	31.6	39.4	46.8	54.8	63.2	70.9	69.8	60.1	49.3	36	27.3	48
		MIN	19	23.1	29.1	34.8	42.4	49.7	56.1	54.5	45.6	36.4	26.8	19.6	36.4
19	BURLEY MUNICIPAL AP	MAX	36.9	43.9	52.8	61.8	70.5	80.6	88.6	87.8	77	64.5	47.7	38	62.5
		MEAN	28.3	34.1	41.5	48.8	56.9	65.3	71.9	70.7	61	50.3	37.4	29	49.6
		MIN	19.7	24.2	30.1	35.8	43.2	50	55.2	53.5	45	36	27.1	19.9	36.6
20	CABINET GORGE	MAX	31.6	37.3	45.7	55.2	64.3	70.8	79.6	79.7	69.7	55.8	39.5	32.4	55.1
		MEAN	26.3	30.4	37	44.5	52.3	58.6	64.9	64.9	56.7	46	34.4	27.8	45.3
		MIN	20.9	23.5	28.2	33.7	40.3	46.3	50.1	50	43.6	36.2	29.3	23.2	35.4
21	CALDWELL	MAX	37.1	46.1	57.4	66.3	75.1	84.2	92.6	91.7	80.8	67	49.3	37.9	65.5
		MEAN	29.1	36.2	45	52.4	60.7	68.5	75.4	73.8	63.3	51.8	38.9	29.6	52.1
		MIN	21.1	26.2	32.6	38.5	46.2	52.8	58.1	55.8	45.8	36.6	28.4	21.3	38.6
22	CAMBRIDGE	MAX	30.8	38.1	51.7	63	72	81	90.6	89.8	79.5	65	45.1	32.6	61.6
		MEAN	23	28.9	40.5	49.3	57.2	65.2	72.6	71.3	61.3	49.4	35.8	24.7	48.3
		MIN	15.1	19.6	29.2	35.5	42.4	49.3	54.5	52.7	43.1	33.8	26.5	16.8	34.9
23	CASCADE 1 NW	MAX	29.2	34.7	42.1	51.1	61.2	70.1	79.4	79.3	69.3	56.8	39	29.8	53.5
		MEAN	19.5	23.6	30.7	38.4	47.1	54.6	61.5	60.7	51.6	41.6	29.5	20.6	40
		MIN	9.7	12.5	19.2	25.7	32.9	39	43.6	42	33.8	26.3	19.9	11.3	26.3
24	CASTLEFORD 2 N	MAX	35.3	42.8	52.8	62.6	71.2	80.3	87.3	85.7	76.1	63.9	46.6	36.1	61.7
		MEAN	27.8	33.8	41.3	48.8	56.3	64.3	70.5	69	60.3	49.9	36.8	28.2	48.9
		MIN	20.2	24.8	29.8	34.9	41.4	48.3	53.6	52.3	44.5	35.8	27	20.3	36.1
26	CHALLIS	MAX	31.4	38.8	49	58.7	67.4	76.8	85.3	84	74.3	61.2	42.7	31.6	58.4
		MEAN	21.9	28.2	37.4	45.4	53.4	61.5	68.6	67.1	57.9	47	32.8	22.2	45.3
		MIN	12.4	17.6	25.8	32	39.4	46.2	51.8	50.1	41.4	32.7	22.9	12.7	32.1
27	CHILLY BARTON FLAT	MAX	30.1	35.3	42.9	53.6	62.8	72.4	81.2	80.2	70.9	58.4	39.9	30.5	54.9
		MEAN	17.4	21.9	30.7	39.7	47.9	56	63	61.7	52.8	42.4	27.7	18.1	39.9
		MIN	4.7	8.4	18.4	25.8	32.9	39.6	44.8	43.1	34.7	26.4	15.5	5.7	25

REVIEW DRAFT

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
28	COBALT	MAX	31.1	38.8	47.2	56.9	65.7	75	84.1	82.9	73.4	60.3	40.7	29.9	57.2
		MEAN	19.4	25.3	33.1	41	48.7	56.2	62.9	61.5	53.2	42.8	29	19	41
		MIN	7.6	11.7	18.9	25.1	31.6	37.4	41.7	40.1	33	25.2	17.2	8.1	24.8
29	COEUR D'ALENE	MAX	34.7	41	49.3	57.8	66.6	73.7	82.6	83.7	73.9	59.9	43.1	35.8	58.5
		MEAN	28.4	33	39.6	46.6	54.7	61.7	68.7	69.2	60.3	48.9	36.7	30.3	48.2
		MIN	22.1	25	29.8	35.4	42.8	49.6	54.8	54.7	46.6	37.9	30.3	24.8	37.8
30	COTTONWOOD 2 WSW	MAX	34.8	39.7	46.1	53.6	61.6	69.2	77.7	79	69.8	57.2	41.4	34.9	55.4
		MEAN	28.9	32.9	38	44.2	51.4	58.6	65.9	66.7	58.3	47.8	35.2	28.9	46.4
		MIN	22.9	26.1	29.8	34.7	41.2	47.9	54	54.3	46.7	38.3	28.9	22.9	37.3
31	COUNCIL	MAX	33.7	40.1	51.1	62	71.5	80.7	90.9	90.8	80.3	65.9	47	35.2	62.4
		MEAN	25.3	30.5	40.1	48.6	56.7	64.7	73	72.6	62.6	50.4	36.9	26.8	49
		MIN	16.8	20.9	29.1	35.1	41.9	48.6	55.1	54.3	44.8	34.9	26.7	18.3	35.5
32	CRATERS OF THE MOON	MAX	29.7	35	43.2	55.2	65.4	75.8	84.9	84.1	73.1	59.8	40.8	30.6	56.5
		MEAN	20.2	24.7	32.3	42.2	51.3	60.3	68.4	67.4	57.1	45.6	30.4	20.9	43.4
		MIN	10.6	14.3	21.3	29.1	37.1	44.7	51.9	50.7	41.1	31.3	19.9	11.1	30.3
33	DEER FLAT DAM	MAX	38	46.1	56.8	65.1	73	80.8	88.2	88	78.9	67.1	50.2	39	64.3
		MEAN	31.2	37.7	46.1	53	60.5	67.4	73.8	73	64.5	53.8	41.3	31.9	52.9
		MIN	24.3	29.3	35.3	40.9	47.9	54	59.3	57.9	50	40.5	32.3	24.8	41.4
34	DIXIE	MAX	30.3	34.6	39.4	46.1	55.8	65.4	74.9	75.5	65.9	53.4	37.6	30.6	50.8
		MEAN	17.2	20.7	26.7	33.7	42.5	50.3	56.3	55.7	47.4	38	25.7	17.6	36
		MIN	4.1	6.7	14	21.2	29.1	35.1	37.7	35.9	28.8	22.6	13.7	4.5	21.1
35	DRIGGS	MAX	28.7	33.1	40.2	51	61.6	71.2	78.8	78.2	68.8	56.6	39.7	29.8	53.1
		MEAN	18.5	22.3	29.7	38.8	47.7	56	62.6	61.5	52.7	42.2	29.1	19.3	40
		MIN	8.3	11.4	19.1	26.5	33.8	40.8	46.3	44.8	36.6	27.8	18.4	8.8	26.9
36	DUBOIS EXPERIMENT STN	MAX	27.9	33	41.9	54.7	64.9	75	84.2	83.7	72.8	58.2	38.9	28.8	55.3
		MEAN	19	23.6	31.8	42.2	51.2	59.8	67.5	66.6	56.7	44.8	29.4	19.8	42.7
		MIN	10	14.1	21.7	29.7	37.5	44.5	50.8	49.5	40.6	31.3	19.9	10.8	30

REVIEW DRAFT

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
37	DWORSHAK FISH HATCHERY	MAX	38.8	45.9	55.2	63.8	72.2	79.3	88.6	89.7	79.5	64.4	47	38.8	63.6
		MEAN	32.5	37.5	44.5	51.5	58.9	65.4	72.4	72.6	63.6	51.6	39.8	33.1	52
		MIN	26.2	29	33.8	39.1	45.6	51.5	56.1	55.4	47.6	38.8	32.6	27.3	40.3
38	ELK CITY 1 NE	MAX	35	41.8	47.3	54.3	62.6	71	80.3	81.7	72	59.4	41.9	33.7	56.8
		MEAN	23.2	28	33.8	40.4	47.8	55	60.8	60.3	52.2	42.8	31.2	22.6	41.5
		MIN	11.4	14.2	20.2	26.4	33	39	41.2	38.8	32.3	26.2	20.4	11.5	26.2
39	ELK RIVER 1 S	MAX	33.7	39.3	46.2	54.4	63.3	70.8	79.2	80.5	70.6	57.6	40.7	33.1	55.8
		MEAN	25.8	29.9	35.8	42.9	50.5	57	62.8	62.8	54.1	44	33.3	25.9	43.7
		MIN	17.9	20.4	25.4	31.3	37.6	43.1	46.3	45.1	37.6	30.3	25.9	18.6	31.6
40	EMMETT 2 E	MAX	36.6	44.9	55	63.2	72.2	81.3	89.9	88.9	78.7	65.9	48.5	37.7	63.6
		MEAN	29.8	36.4	44	50.6	58.6	66.8	74	72.9	63.6	52.5	39.5	30.9	51.6
		MIN	23	27.8	32.9	37.9	45	52.2	58	56.8	48.5	39.1	30.5	24	39.6
41	FAIRFIELD RANGER STN	MAX	30.8	36.2	44.5	56.9	67.1	76.1	85.3	84.9	75.6	63.4	43.3	31.5	58
		MEAN	18.4	22.6	31.6	42.7	51.5	59	66.4	65.2	56.1	45.5	30.7	19.4	42.4
		MIN	5.9	9	18.6	28.5	35.9	41.9	47.4	45.5	36.5	27.5	18	7.2	26.8
42	FENN RANGER STN (LOWELL	MAX	35.7	42.2	52	61.6	70.7	78.1	87.6	88.3	76	60.8	44.2	35.6	61.1
		MEAN	30.9	35.3	42.4	49.4	56.8	63.5	70.4	70.4	60.9	49.5	38.3	31.3	49.9
		MIN	26	28.3	32.7	37.1	42.9	48.9	53.1	52.4	45.8	38.2	32.3	26.9	38.7
43	FORT HALL 1 NNE	MAX	31.1	37.5	47.4	57.2	66.1	75.6	84.2	84.1	74.2	61.4	43.6	32.4	57.9
		MEAN	22.2	27.6	36.1	43.9	52	60	66.5	65.6	56.6	45.7	32.8	23	44.3
		MIN	13.2	17.6	24.8	30.5	37.8	44.4	48.7	47.1	39	29.9	22	13.5	30.7
44	GARDEN VALLEY	MAX	34.3	41.4	51.2	61	70.3	79.2	88.4	88.3	78.1	64.7	43.8	33.6	61.2
		MEAN	25.9	30.9	38.8	46.2	53.9	61.3	67.7	66.8	58	47.5	34.4	25.9	46.4
		MIN	17.4	20.3	26.3	31.4	37.4	43.4	47	45.2	37.8	30.3	25	18.1	31.6
45	GIBBONSVILLE	MAX	28.1	35.3	45.5	55.6	64.6	73.2	83.1	81.8	71.9	58	38.7	28.2	55.3
		MEAN	18.8	24.2	33.4	41.5	49.2	56.5	63.7	62.4	53.8	42.9	29.5	19.3	41.3
		MIN	9.4	13.1	21.2	27.3	33.7	39.8	44.3	42.9	35.6	27.8	20.3	10.4	27.2

REVIEW DRAFT

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
46	GLENNS FERRY	MAX	39.8	47.6	57.5	66.7	75.4	85.9	95.2	93.7	82.6	68.9	51	40.1	67
		MEAN	30.4	35.9	43.2	50.3	58	66.7	73.9	72.1	61.9	50.5	38.4	30.2	51
		MIN	20.9	24.2	28.8	33.8	40.6	47.4	52.5	50.5	41.1	32.1	25.8	20.2	34.8
47	GRACE	MAX	31.1	36.5	45.5	56.5	66.1	76.2	85	84.9	74.9	61.6	43.1	33	57.9
		MEAN	21.2	25.1	33.8	42.7	51.2	59.3	66.3	65.6	56.5	45.6	32	22.7	43.5
		MIN	11.3	13.7	22	28.9	36.2	42.4	47.5	46.2	38	29.5	20.9	12.4	29.1
48	GRAND VIEW 4 NW	MAX	38.4	47.2	57.7	66.1	74.5	83	90.7	89.8	79.3	66.5	49.5	38.3	65.1
		MEAN	29.9	36.4	44.3	51.6	59.7	67.4	73.5	71.9	62	51	38.7	29.6	51.3
		MIN	21.4	25.5	30.8	37	44.9	51.7	56.3	53.9	44.7	35.4	27.9	20.8	37.5
49	GRANGEVILLE	MAX	38.1	44	50.4	57.7	64.9	72.3	81.6	82.9	72.8	59.9	45.2	37.9	59
		MEAN	31.2	35.3	40.3	46.3	53.3	60.1	66.9	67.3	58.3	48.1	37.7	31.1	48
		MIN	24.3	26.6	30.2	34.8	41.6	47.9	52.2	51.7	43.7	36.2	30.1	24.2	37
50	GROUSE	MAX	26.6	32.2	40.5	50.4	60.6	69.6	78.7	77.6	68.7	56.6	38.3	27.8	52.3
		MEAN	12.4	17.1	27	37	46.4	53.5	59.8	58.7	50.3	39.5	24.8	14	36.7
		MIN	-1.8	2	13.4	23.5	32.2	37.3	40.9	39.7	31.8	22.3	11.2	0.1	21.1
51	HAGERMAN 2 SW	MAX	40.8	49	58.3	67.5	76.4	85.6	94.5	93.4	83.2	70.8	52.4	41.3	67.8
		MEAN	30.2	36.3	43.9	51.1	59.4	67.4	74	72.2	62.6	52.1	39.5	30.7	51.6
		MIN	19.6	23.6	29.4	34.7	42.4	49.2	53.4	51	42	33.3	26.6	20.1	35.4
53	HAMER 4 NW	MAX	28.3	35	47	59.9	69.3	78.8	87	85.9	75.6	62	41.9	29.6	58.4
		MEAN	16.4	22.5	33.5	43.8	53.1	61.3	67.5	65.7	55.9	44.2	29	17.5	42.5
		MIN	4.4	10	19.9	27.6	36.9	43.8	47.9	45.5	36.1	26.4	16	5.3	26.7
54	HAZELTON	MAX	34.9	41.7	51.2	60.6	69.3	79.5	88.1	87.4	77.2	64.5	46.5	36.2	61.4
		MEAN	26.5	32	39.7	47	55.3	64.1	71.2	69.8	59.9	48.9	35.9	27.3	48.1
		MIN	18.1	22.2	28.2	33.4	41.2	48.6	54.2	52.1	42.6	33.2	25.2	18.3	34.8
55	HEADQUARTERS	MAX	34.8	39.8	46.1	54.5	63.5	71.3	79.7	81	70.5	58	41.3	33.9	56.2
		MEAN	26.6	30	35.4	42	49.4	56.5	62.3	62.5	53.5	43.9	33.1	26.4	43.5
		MIN	18.3	20.2	24.7	29.4	35.3	41.7	44.9	43.9	36.5	29.8	24.9	18.9	30.7

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
56	HILL CITY 1 W	MAX	29.3	33.8	41.8	54.4	65.1	74.6	84.3	84.3	74.5	61.8	41.8	30.7	56.4
		MEAN	18.7	22.8	31.4	42	50.4	57.3	64.5	63.9	54.9	44.5	30.2	19.6	41.7
		MIN	8.1	11.7	21	29.6	35.7	39.9	44.7	43.4	35.3	27.2	18.6	8.4	27
57	HOLLISTER	MAX	37.3	43.4	51.2	59.8	68	77.8	86.1	84.9	75.1	62.9	47.4	38.8	61.1
		MEAN	28.4	33.4	39.5	46.1	53.6	62.2	70	69.1	60.2	49.5	37.4	29.4	48.2
		MIN	19.5	23.3	27.7	32.4	39.2	46.5	53.8	53.3	45.3	36.1	27.4	19.9	35.4
58	HOWE	MAX	30.7	36.9	48	60.6	69.1	78.1	86.9	85.7	75.1	61.5	43	31.4	58.9
		MEAN	18.4	24.3	35.2	45.1	53.3	61.4	68.1	66.6	56.6	45.2	30.3	18.9	43.6
		MIN	6	11.6	22.3	29.6	37.4	44.6	49.3	47.5	38.1	28.8	17.6	6.3	28.3
59	IDAHO CITY	MAX	34.9	41	48	57.3	66.8	76.1	85.8	85.6	75.4	62.8	43.8	34.8	59.4
		MEAN	23.6	28	35	42.5	50.7	58.2	65.1	64.3	55.1	44.8	32.1	23.7	43.6
		MIN	12.2	15	21.9	27.6	34.6	40.2	44.4	43	34.8	26.8	20.4	12.6	27.8
60	IDAHO FALLS 2 ESE	MAX	29.7	36.6	47.6	58.7	67.9	77.8	86	85.8	75.1	61.4	43	31.3	58.4
		MEAN	21.1	26.7	36.2	45	53.3	61.9	68.7	67.9	58.2	46.8	33.1	22.4	45.1
		MIN	12.5	16.8	24.8	31.3	38.7	46	51.4	49.9	41.3	32.2	23.2	13.4	31.8
61	IDAHO FALLS 16 SE	MAX	29.7	34.5	41.1	50.7	60.2	69.6	78.1	77.2	67.9	55.7	39	30	52.8
		MEAN	18.9	23.3	30.6	38.7	46.8	54.1	60.7	59.6	51	40.7	27.6	18.9	39.2
		MIN	8.1	12	20	26.6	33.3	38.5	43.2	42	34.1	25.6	16.2	7.7	25.6
62	IDAHO FALLS FANNING AP	MAX	27.5	33.9	45.8	57.3	66.6	77	85.9	85.1	74	59.8	41.5	29.5	57
		MEAN	19.3	24.8	35.4	44.6	52.9	61.5	68.4	67.1	57.3	45.5	31.8	20.8	44.1
		MIN	11.1	15.6	25	31.9	39.1	46	50.8	49.1	40.6	31.1	22.1	12.1	31.2
63	IDAHO FALLS 46 W	MAX	27.9	34	44.8	56.9	66.3	76.8	86.6	85.7	74.6	60.9	41.4	29.4	57.1
		MEAN	16.2	22.1	32.8	42.4	51.2	60	67.6	66.2	55.7	43.4	28.7	17.1	42
		MIN	4.5	10.2	20.7	27.9	36.1	43.2	48.5	46.7	36.8	25.9	15.9	4.8	26.8
64	ISLAND PARK	MAX	26.5	31.2	38	47.9	58.7	69.8	78.8	79.3	69.7	55.7	36.7	27	51.6
		MEAN	15.9	19.2	26.4	35.6	45.4	53.9	60.6	59.9	51.2	40.5	26.1	16.4	37.6
		MIN	5.3	7.2	14.8	23.3	32.1	38	42.4	40.5	32.6	25.3	15.5	5.8	23.6

REVIEW DRAFT

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
65	JEROME	MAX	35.6	42.3	52.1	61.6	70.8	81	90.2	89.5	78.3	65.2	47.5	36.9	62.6
		MEAN	27	32.2	39.9	47.3	56	64.8	72.6	71.5	61.5	50.2	36.6	27.8	49
		MIN	18.3	22	27.7	33	41.1	48.6	54.9	53.5	44.6	35.1	25.7	18.6	35.3
67	KELLOGG	MAX	35.7	41.6	49.5	58.6	67.5	74.6	82.6	82.6	72.2	58.4	42.7	35.3	58.4
		MEAN	28.3	32.8	39.2	46.3	54	60.6	66.4	66	57	45.9	35.4	28.6	46.7
		MIN	20.9	24	28.8	33.9	40.5	46.5	50.2	49.4	41.7	33.4	28.1	21.9	34.9
68	KETCHUM RANGER STN	MAX	31.6	37	43.7	53.5	62.9	72.1	80.9	79.9	70.1	58.7	42	32.3	55.4
		MEAN	17.8	22.2	29.6	38.9	47.4	54.8	61.9	60.3	51.7	41.7	28.2	18.9	39.5
		MIN	3.9	7.4	15.4	24.2	31.8	37.5	42.8	40.6	33.2	24.7	14.4	5.4	23.4
69	KOOSKIA 5 SSE	MAX	35.8	42.8	50.7	58.5	66.5	73.1	82.5	85.9	74.8	60.8	44.3	36.1	59.3
		MEAN	29.2	34.1	40.8	47.6	55.1	61.1	68.2	69.4	60.5	49.1	37	29.6	48.5
		MIN	22.5	25.4	30.9	36.7	43.6	49	53.8	52.9	46.1	37.3	29.7	23.1	37.6
70	KUNA	MAX	36.7	45.7	56.7	65.3	73	81.7	89.2	88	78.3	66.1	48.6	37.4	63.9
		MEAN	29.4	36.5	44.6	51	58.3	65.9	71.8	70.5	61.6	51.2	38.8	29.7	50.8
		MIN	22.1	27.2	32.5	36.6	43.6	50	54.3	52.9	44.8	36.3	28.9	21.9	37.6
71	LEADORE NO 2	MAX	29.8	35.4	43.4	53.8	63.3	73.3	82.7	81.2	71.2	57.7	39	29.2	55
		MEAN	16	21.3	30	39.2	47.6	55.7	62.1	60.6	51.9	40.8	26.4	16.1	39
		MIN	2.1	7.1	16.6	24.6	31.9	38.1	41.4	40	32.5	23.9	13.7	2.9	22.9
72	LEWISTON AP	MAX	39.4	45.6	53.8	61.6	70	78	87.6	87.6	76.7	62	46.8	39.2	62.4
		MEAN	33.7	38.4	44.7	51.1	58.5	65.8	73.5	73.4	63.8	51.6	40.4	33.9	52.4
		MIN	28	31.2	35.6	40.6	47	53.6	59.3	59.3	50.9	41.2	34.1	28.5	42.4
73	LIFTON PUMPING STN	MAX	28.8	32.1	40.3	50.8	60.9	71.2	79.3	78.2	68.1	55.4	39.6	30.4	52.9
		MEAN	17.4	19.2	28.8	40.2	50.1	58.9	65.3	63	53.4	42.2	29.6	20	40.7
		MIN	5.9	6.2	17.3	29.5	39.3	46.6	51.3	47.8	38.7	29	19.5	9.6	28.4
74	LOWMAN	MAX	32.7	39.5	48.2	57.8	66.6	75.4	84.9	84.7	75.1	61.8	41.3	31.8	58.3
		MEAN	23.6	28.7	36.2	43.9	51.5	58.5	64.5	63.5	55.2	45.3	32.7	23.1	43.9
		MIN	14.4	17.8	24.1	30	36.3	41.5	44.1	42.2	35.3	28.7	24	14.4	29.4

REVIEW DRAFT

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
75	MACKAY LOST RIVER RS	MAX	30.4	35.7	44.1	55.8	65.3	74.9	83.8	82.5	73.1	60.1	41.4	30.7	56.5
		MEAN	18.4	23.1	31.9	41.7	50.4	58.5	65.6	64.1	55.4	44.5	29.7	19.1	41.9
		MIN	6.4	10.4	19.6	27.6	35.4	42.1	47.3	45.6	37.7	28.9	18	7.5	27.2
76	MALAD CITY AP	MAX	31.1	37.8	48.6	58.5	68	79.2	88.3	87.2	77	63.5	45.4	33.6	59.9
		MEAN	20.8	25.8	35.6	43.2	52.1	60.8	68	66.7	57.2	45.8	32.8	22.7	44.3
		MIN	10.4	13.7	22.5	27.9	36.1	42.3	47.7	46.2	37.3	28.1	20.2	11.8	28.7
77	MALTA 4 ESE	MAX	36	42.3	51.4	60.7	69	79.1	87.6	86.8	76.2	63.5	46.4	37	61.3
		MEAN	26.5	32	39.2	46.3	53.9	61.7	68.8	67.7	58.2	47.8	35.2	26.9	47
		MIN	16.9	21.6	27	31.9	38.7	44.3	49.9	48.5	40.1	32	23.9	16.7	32.6
79	MASSACRE ROCKS ST PARK	MAX	34.7	41.8	51.3	60.8	70.2	81.1	90.4	89.8	79	65.1	46.1	36	62.2
		MEAN	24.6	30.5	38.4	46.1	55	64	71.7	70.5	60.7	48.7	34.7	25.8	47.6
		MIN	14.4	19.2	25.5	31.4	39.7	46.9	52.9	51.2	42.3	32.3	23.3	15.5	32.9
80	MAY 2 SSE	MAX	30.3	37.8	47.7	57	66.1	76.2	85.3	83.6	74.4	60.8	41.7	30.3	57.6
		MEAN	18.3	24.6	34.2	41.9	50.4	58.8	65.5	63.4	55	43.6	29.2	18.6	42
		MIN	6.3	11.4	20.6	26.7	34.7	41.3	45.7	43.1	35.5	26.3	16.6	6.9	26.3
81	MCCALL	MAX	31.2	36.6	42.9	51.4	61.1	70	79.7	80.1	70	57.8	39.7	31.2	54.3
		MEAN	21.9	25.8	31.8	39.2	47.5	54.7	61.3	60.6	51.6	42.2	30.8	22.7	40.8
		MIN	12.6	14.9	20.6	27	33.8	39.4	42.9	41	33.2	26.5	21.9	14.1	27.3
82	MCCAMMON	MAX	30.5	36.6	47.6	58.3	67.1	77.3	85.5	84.2	74.7	61.8	43.4	32.5	58.3
		MEAN	23.1	27.5	36.8	45.2	52.8	61.1	67.9	66.8	57.8	46.9	33.7	24.3	45.3
		MIN	15.6	18.4	25.9	32	38.5	44.9	50.3	49.4	40.9	32	24	16.1	32.3
83	MIDDLE FORK LODGE	MAX	34.9	41.9	50.8	59.2	67.7	76.5	85.9	85	75.7	62.3	43.6	33.9	59.8
		MEAN	23.7	28.7	37	43.9	51.6	58.8	65.7	64.5	56.1	45.4	32.3	23.4	44.3
		MIN	12.5	15.5	23.1	28.6	35.4	41.1	45.5	44	36.4	28.4	20.9	12.9	28.7
84	MINIDOKA DAM	MAX	35.4	41.8	51.1	60	69	79.3	88.3	88.1	77.8	64.6	47.4	36.8	61.6
		MEAN	25.4	30.8	38.8	46.5	55.1	63.9	71.3	70.5	61.1	49.5	36.2	26.9	48
		MIN	15.4	19.8	26.5	33	41.2	48.5	54.2	52.9	44.3	34.3	25	16.9	34.3

REVIEW DRAFT

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
85	MONTPELIER RANGER STN	MAX	30.4	34.5	42.8	53.6	64	74.8	84.7	84.7	73.4	60	41.5	31.9	56.4
		MEAN	19.2	21.1	30.5	39.8	49.4	58.4	66.5	65.3	55	43.8	29.7	20.6	41.6
		MIN	7.9	7.7	18.2	25.9	34.8	42	48.2	45.8	36.5	27.5	17.8	9.3	26.8
86	MOSCOW U OF I	MAX	35.6	41.3	49	57.5	65.9	73.1	82.6	84	74.4	60.5	43.1	35.5	58.5
		MEAN	29.4	34.1	40.1	46.5	53.3	59.2	65.5	66.4	58.7	48.3	36.5	29.6	47.3
		MIN	23.2	26.8	31.2	35.4	40.6	45.2	48.4	48.7	42.9	36	29.9	23.6	36
87	MOUNTAIN HOME	MAX	37.6	44.9	53.6	62.5	71.6	82.3	91.7	91.2	79.5	66.2	48.5	38.2	64
		MEAN	29	34.7	41.7	48.8	57.2	66.4	74.2	73.4	62.7	50.8	37.7	29.3	50.5
		MIN	20.4	24.4	29.7	35.1	42.8	50.4	56.7	55.5	45.8	35.4	26.9	20.3	37
88	NAMPA SUGAR FACTORY	MAX	37	44.5	55.3	63.6	72.7	82	90.5	89.4	78.7	66.1	49.1	38.8	64
		MEAN	28.9	35.1	43.2	50	58.2	66.4	73.3	71.8	62.1	51.1	38.7	30.1	50.7
		MIN	20.8	25.7	31.1	36.4	43.6	50.7	56	54.2	45.4	36	28.3	21.3	37.5
89	NEW MEADOWS RANGER STN	MAX	29.7	36.5	45.5	55	64.3	73.2	82.7	83.1	72.8	60.2	41.3	30.2	56.2
		MEAN	18.9	23.8	32.6	40.8	48.6	56.1	62.4	61.8	52.7	42.5	30.6	19.8	40.9
		MIN	8	11	19.7	26.6	32.9	39	42.1	40.4	32.5	24.7	19.8	9.3	25.5
90	NEZPERCE	MAX	34.9	41	47.7	55.4	63.1	70.4	79.5	80.7	71	58	42.2	34.8	56.6
		MEAN	28.3	33.1	38.5	44.5	51.3	57.6	64.1	64.7	56.4	46.3	35.1	28.5	45.7
		MIN	21.7	25.1	29.2	33.6	39.4	44.7	48.6	48.6	41.8	34.5	27.9	22.1	34.8
91	OAKLEY	MAX	36.6	42.6	50.5	58.7	66.6	76	83.1	83.1	73.8	62.4	46	37.4	59.7
		MEAN	27.9	32.9	39.4	45.8	53.4	61.8	68.6	68.3	59.3	49.1	36.3	28.4	47.6
		MIN	19.1	23.2	28.2	32.9	40.1	47.5	54.1	53.5	44.7	35.8	26.6	19.4	35.4
92	OLA 4 S	MAX	34.1	42.5	53.9	63.3	72.3	80.9	89.7	89	78.8	64.4	45.4	34.5	62.4
		MEAN	24.6	31.4	40.1	47.2	55.2	63	70.3	68.8	59.4	47.5	34.6	25.3	47.3
		MIN	15.1	20.2	26.3	31.1	38.1	45	50.9	48.6	39.9	30.6	23.7	16.1	32.1
93	OROFINO	MAX	37.7	45.8	55.4	64	72	79.7	88.9	90.2	78.8	63.2	46.1	37.3	63.3
		MEAN	31.5	36.9	43.7	50.9	58.1	65	71.3	71.6	62.1	49.8	38.6	31.8	50.9
		MIN	25.2	28	32	37.8	44.1	50.3	53.7	52.9	45.3	36.4	31.1	26.2	38.6

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
94	PALISADES	MAX	31	36.6	45.3	56.1	65.8	75.9	84.7	83.8	74.8	61.5	43	32.1	57.6
		MEAN	23.2	26.7	34.4	43.4	52.2	61.1	68.6	67.4	58.8	48.1	34.5	24.9	45.3
		MIN	15.3	16.7	23.4	30.7	38.6	46.3	52.5	51	42.7	34.6	25.9	17.6	32.9
95	PARMA EXPERIMENT STN	MAX	35.5	43.6	55.7	64.5	72.8	81.5	90.6	90.4	79.7	66.6	48.5	36.9	63.9
		MEAN	27.2	34	42.9	50.1	58.2	65.7	72.4	71.2	61.4	50.1	37.5	28.3	49.9
		MIN	18.8	24.3	30.1	35.7	43.6	49.8	54.2	52	43.1	33.5	26.5	19.7	35.9
96	PAUL 1 ENE	MAX	35.1	41.7	51.2	60.3	68.8	78.7	87.4	87.3	76.4	63.9	46.8	36.6	61.2
		MEAN	26.4	31.6	39.4	46.7	54.8	63.4	70.4	69.3	59.3	48.6	35.9	27.3	47.8
		MIN	17.7	21.5	27.5	33	40.8	48.1	53.4	51.2	42.1	33.2	25	17.9	34.3
97	PAYETTE	MAX	36.7	45.8	57.7	66.1	74.3	82.4	90.8	89.6	80.1	67.6	50.1	38.7	65
		MEAN	28.1	35.4	44.8	51.9	60.1	67.8	74.9	73.5	64.1	52.4	39.4	30	51.9
		MIN	19.5	24.9	31.8	37.7	45.9	53.2	58.9	57.3	48.1	37.1	28.6	21.3	38.7
98	PICABO	MAX	30.9	36.7	45.6	56.8	65.7	75.4	84.7	84.2	73.4	61.1	42.4	31.9	57.4
		MEAN	18.8	23.9	32.8	42	50	58	65.4	64.7	55.1	44.5	30.3	20.4	42.2
		MIN	6.7	11	19.9	27.1	34.3	40.6	46	45.1	36.8	27.9	18.1	8.8	26.9
99	PIERCE	MAX	33.2	37.9	45.6	54.3	64	71.7	81.4	82.6	72.3	59	40.5	33	56.3
		MEAN	25	28.2	34.3	41.4	49.6	56.2	62.4	61.9	53.1	43.1	32.2	25.3	42.7
		MIN	16.7	18.4	23	28.5	35.1	40.7	43.4	41.2	33.8	27.2	23.9	17.6	29.1
100	POCATELLO RGNL AP	MAX	32.5	39	48.5	58.5	67.7	78.3	87.5	86.8	75.7	62	44.5	33.8	59.6
		MEAN	24.4	30	37.9	45.6	53.5	62	69.2	68.4	58.8	47.7	34.7	25.3	46.5
		MIN	16.3	20.9	27.3	32.6	39.2	45.7	50.9	49.9	41.8	33.3	24.9	16.8	33.3
101	PORTHILL	MAX	33.3	38.8	48.5	59.3	68.1	74.5	81.6	81.8	71.2	56.7	41.6	33.8	57.4
		MEAN	25.6	30.2	37.9	46.5	54.6	60.9	66.3	65.4	55.8	44.4	34	26.6	45.7
		MIN	17.8	21.5	27.2	33.6	41.1	47.3	51	49	40.4	32	26.3	19.3	33.9
102	POTLATCH 3 NNE	MAX	36	41.7	48.5	56.8	64.8	71.6	80.4	81.9	72.8	59.8	43.2	36.1	57.8
		MEAN	29	33.5	38.8	45	51.4	57.1	62.6	62.8	55.1	45.5	35.7	29.2	45.5
		MIN	21.9	25.2	29.1	33.1	37.9	42.6	44.7	43.7	37.3	31.2	28.2	22.3	33.1

REVIEW DRAFT

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
103	POWELL	MAX	30.9	37	44.6	53.5	63.3	71.4	80.4	80.4	69.4	56.2	37.8	30	54.6
		MEAN	24.1	28.2	34.6	41.4	49	56.4	62.6	62.1	52.9	43.1	31	23.7	42.4
		MIN	17.3	19.3	24.5	29.2	34.7	41.4	44.8	43.7	36.4	30	24.2	17.3	30.2
104	PRESTON	MAX	30.3	36.6	47.7	57.9	67.5	78	87.1	86.1	76.1	62.5	44.6	32.8	58.9
		MEAN	21.3	26.4	36.6	45	53.5	61.9	69.4	68.2	58.6	46.9	33.6	23.3	45.4
		MIN	12.2	16.2	25.5	32.1	39.5	45.8	51.6	50.3	41.1	31.3	22.6	13.8	31.8
105	PRIEST RIVER EXP STN	MAX	30.4	36.1	45.4	56.6	66.5	73.5	81.4	81.7	71.1	55.5	37.6	30.6	55.5
		MEAN	24.6	28.7	35.2	43.1	51.8	58.1	63.5	63.1	54.1	43	31.6	25.4	43.5
		MIN	18.7	21.3	24.9	29.6	37	42.7	45.6	44.5	37.1	30.4	25.6	20.1	31.5
106	REXBURG RICKS COLLEGE	MAX	28.5	33.9	45	56.8	65.7	74.6	83.6	84	74	59.7	40.9	29.6	56.4
		MEAN	19.3	24.2	33.7	43.2	51.8	59.6	66.1	65.2	55.8	44.2	30.3	19.6	42.8
		MIN	10	14.5	22.4	29.6	37.8	44.5	48.6	46.4	37.6	28.6	19.6	9.6	29.1
107	REYNOLDS	MAX	38.9	44	51	58.9	67.3	76.9	85.7	85.5	74.8	63.3	48	39.4	61.1
		MEAN	29.3	33.7	39.4	45.6	53.3	61.2	68.8	68.2	58.2	47.8	36.5	29.2	47.6
		MIN	19.6	23.4	27.7	32.3	39.2	45.5	51.8	50.9	41.5	32.3	24.9	18.9	34
108	RICHFIELD	MAX	30.2	36.3	47.2	58.2	67	76.7	85.4	85	74.9	61.9	43.2	32.1	58.2
		MEAN	22.2	27.4	36.6	45	53.2	61.3	68.5	67.8	58.4	47	33.3	23.8	45.4
		MIN	14.1	18.5	26	31.7	39.3	45.8	51.6	50.5	41.9	32	23.4	15.4	32.5
109	RIGGINS	MAX	40.9	48.5	56.9	65	72.7	80.6	90.2	90.9	80.3	66.4	49.3	41	65.2
		MEAN	33.9	39.4	45.9	52.5	59.4	66.5	74	74.2	64.9	53.5	41.1	34.4	53.3
		MIN	26.9	30.3	34.9	39.9	46	52.3	57.7	57.4	49.5	40.5	32.9	27.8	41.3
110	RUPERT 3 WSW	MAX	34.4	40.5	50.2	59.9	68.2	77.7	85.5	85.6	75.7	63.4	46.2	35.9	60.3
		MEAN	25	30.2	38.1	45.8	53.5	61.6	67.7	66.8	57.5	46.8	34.5	25.8	46.1
		MIN	15.5	19.8	25.9	31.6	38.8	45.5	49.9	47.9	39.2	30.2	22.8	15.6	31.9
111	SAINT ANTHONY 1 WNW	MAX	28.8	34	43.6	55.7	65.6	74.4	82.8	82.7	73	60.1	41.7	30.3	56.1
		MEAN	17.9	21.6	30.6	40.6	50	57.8	64.3	63	54.1	43.3	29.3	19	41
		MIN	6.9	9.2	17.5	25.4	34.3	41.2	45.8	43.3	35.1	26.4	16.9	7.6	25.8

REVIEW DRAFT

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
112	SAINT MARIES 1 W	MAX	34.4	41	49.6	58.5	66.7	74	82.9	83.7	73.3	58	40.9	33.8	58.1
		MEAN	28.9	33.7	39.9	46.6	53.8	60.4	66.6	66.8	57.8	46.3	35.3	28.8	47.1
		MIN	23.3	26.3	30.1	34.7	40.9	46.7	50.2	49.8	42.3	34.6	29.6	23.8	36
113	SALMON KSRA	MAX	28.4	37	49.7	59.9	69.1	77.9	87.3	85.5	74.9	60.3	40.7	29.2	58.3
		MEAN	18.9	26.1	37.2	45.9	54.3	62	69.1	67	57.7	45.3	30.9	20.3	44.6
		MIN	9.3	15.2	24.7	31.8	39.5	46.1	50.9	48.5	40.4	30.2	21	11.4	30.8
114	SANDPOINT EXP STATION	MAX	31.6	37.6	46.5	56.4	65.4	72.1	80.1	80.2	70	56.1	40	32.4	55.7
		MEAN	25.5	30.2	37.3	45.3	53.2	59.4	64.9	64.5	55.7	44.7	33.8	26.9	45.1
		MIN	19.4	22.8	28.1	34.2	40.9	46.7	49.7	48.7	41.4	33.2	27.5	21.4	34.5
115	SHOSHONE 1 WNW	MAX	33.4	40.2	51.1	62.1	72	82.7	91.4	90.4	78.6	64.5	45.7	35.1	62.3
		MEAN	25.2	30.6	39.3	47.9	56.8	65.9	73.7	72.7	62	50	35.8	26.6	48.9
		MIN	16.9	21	27.4	33.6	41.6	49.1	55.9	54.9	45.3	35.4	25.9	18	35.4
116	SHOUP	MAX	31.2	39.6	52.1	63	71.9	80.7	89.8	88.7	78.1	61.9	42.1	30.7	60.8
		MEAN	23.1	29.6	40	48.3	55.9	63.3	70.4	69.4	60.1	47.5	33.7	23.5	47.1
		MIN	15	19.5	27.8	33.5	39.8	45.9	51	50	42.1	33.1	25.2	16.2	33.3
117	SILVER CITY 5 W	MAX	35.7	39.3	44	51.6	60.4	71.1	80.9	80.9	71.1	59	43.3	37.1	56.2
		MEAN	28.2	31	35.1	41.3	49.9	58.8	68.1	68.1	59.1	48.2	34.5	28.8	45.9
		MIN	20.7	22.6	26.1	30.9	39.4	46.5	55.2	55.3	47.1	37.4	25.6	20.5	35.6
118	SODA SPRINGS AP	MAX	28.6	32.2	40.5	52.3	63	73.9	83.2	81.8	71.3	58.1	40.6	30.2	54.6
		MEAN	18.4	21.6	29.7	39.5	48.8	57.3	64.2	63	53.3	42.2	29.5	19.2	40.6
		MIN	8.1	10.9	18.9	26.6	34.5	40.7	45.2	44.1	35.3	26.3	18.3	8.1	26.4
119	STANLEY	MAX	27	33.9	42.3	49.7	59	68.1	77.8	77.6	68.4	56.3	37.8	26	52
		MEAN	12.7	16.7	25.4	34.5	43.7	51.2	57.2	56.1	48.1	39.1	25.2	12.5	35.2
		MIN	-1.7	-0.6	8.5	19.2	28.4	34.2	36.6	34.6	27.7	21.8	12.6	-1	18.4
120	SWAN FALLS P H	MAX	39.6	48	58.2	66.6	75.7	85.6	94.5	93.3	83	69.2	50.8	40.2	67.1
		MEAN	31.6	38	46.5	53.7	62.1	70.9	78.6	77.2	67.2	55.3	41	32.1	54.5
		MIN	23.5	27.9	34.7	40.8	48.5	56.1	62.7	61	51.4	41.3	31.1	23.9	41.9

REVIEW DRAFT

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
121	SWAN VALLEY 2 E	MAX	29.6	35.4	44.1	54.9	64.4	74.7	83.7	82.9	73.1	59.7	41.2	30.6	56.2
		MEAN	20.7	25.1	33.5	41.9	50.2	58.4	65.2	64.3	55.3	44.3	31.2	21.5	42.6
		MIN	11.7	14.8	22.8	28.9	36	42	46.6	45.7	37.5	28.8	21.1	12.4	29
122	TAYLOR RANCH	MAX	27.8	36.1	46.7	56.6	65.7	74.2	84.3	83.9	72.8	56.4	38	27.9	55.9
		MEAN	20.5	26.6	35.6	43.2	50.8	57.9	65	64.3	55.3	43.3	30.6	21.6	42.9
		MIN	13.1	17.1	24.4	29.7	35.9	41.6	45.7	44.6	37.7	30.1	23.2	15.3	29.9
123	TETONIA EXPERIMENT STN	MAX	27	33.1	39.8	49.2	60.6	70.5	78.7	77.9	68.6	55.6	37.8	27.9	52.2
		MEAN	15.3	20.7	27.9	37.2	46.7	54.9	61.5	60.4	51.3	40.4	26.3	16.1	38.2
		MIN	3.5	8.2	16	25.1	32.8	39.2	44.3	42.8	34	25.1	14.7	4.2	24.2
124	TWIN FALLS KMVT	MAX	36.6	43.3	52.3	61	69.8	79.1	87.9	86.7	76.6	64.7	48.2	37.9	62
		MEAN	28.2	33.2	40.7	47.9	56.3	64.9	72.2	70.4	60.7	50.1	37.7	29	49.3
		MIN	19.7	23.1	29.1	34.7	42.7	50.6	56.5	54.1	44.8	35.5	27.2	20	36.5
125	TWIN FALLS 6 E	MAX	34.9	41.4	50.7	59.5	67.7	77	85	84.1	74.2	62.5	46.2	36.4	60
		MEAN	27.1	32.4	39.8	46.6	54.5	62.5	68.9	67.6	58.5	48.4	36.3	27.9	47.5
		MIN	19.2	23.4	28.8	33.7	41.2	48	52.8	51.1	42.8	34.2	26.4	19.3	35.1
126	WALLACE WOODLAND PARK	MAX	33.6	38.9	46	54.7	63.1	70	78.3	79.3	69.6	57.2	40.7	33.3	55.4
		MEAN	26.7	30.8	36.6	43.7	51.1	57.6	63.6	63.9	55.2	45.2	34.1	27.1	44.6
		MIN	19.8	22.6	27.1	32.7	39	45.2	48.9	48.4	40.7	33.2	27.5	20.9	33.8
127	WARREN	MAX	34.2	39.3	43.6	49.6	58.2	67.1	76.1	75.8	67.1	56	39.7	32.7	53.3
		MEAN	20.1	23.9	28.5	34.4	42.2	49.3	55.4	54.7	47.4	39.4	27.5	19.9	36.9
		MIN	5.9	8.4	13.4	19.2	26.1	31.4	34.6	33.6	27.6	22.8	15.2	7	20.4
128	WEISER	MAX	34.8	43.5	56	64.6	73.3	82.2	91.2	89.6	79.7	66.1	47.7	36.2	63.7
		MEAN	27.7	34.8	44.9	52.2	60.5	68.6	75.6	73.7	64	52.1	39	29.3	51.9
		MIN	20.6	26.1	33.7	39.7	47.6	54.9	59.9	57.8	48.3	38	30.3	22.3	39.9
129	WINCHESTER	MAX	35.2	39.7	44.7	52.2	59.6	67.3	76.1	77.8	68.6	56.7	41.4	34.9	54.5
		MEAN	27.5	31.1	35.4	41.6	48.2	54.8	61	61.7	53.8	44.6	33.7	27.3	43.4
		MIN	19.7	22.4	26.1	31	36.7	42.2	45.9	45.6	39	32.5	25.9	19.7	32.2

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
130	YELLOW PINE 7 S	MAX	32.8	38.6	44.9	52.3	61.5	70.1	79.8	79.7	70.3	58	40.3	32.3	55.1
		MEAN	20.2	24.2	30.6	37.3	45.3	52.2	58.7	57.9	49.9	40.9	28.8	20.5	38.9
		MIN	7.6	9.7	16.2	22.2	29.1	34.3	37.6	36	29.4	23.7	17.3	8.6	22.6

4.4.7 The Leaching Requirement (LR) and LR Calculations

The leaching fraction (LF) is the ratio of deep percolation to the applied water. The leaching requirement (LR), as stated in Section 4.1.1.2.2, is the fraction of the irrigation water that must be leached through the crop root zone to control soil salinity at any specified level. The same ratio of deep percolation to applied water exists between the concentration (mg/L) of the conservative mineral salts applied and the concentration of conservative mineral salts in the percolate. There are several valid approaches to determining the leaching requirement, not all of which are discussed below. The following equations used to analyze irrigation related salinity issues typically express salinity in terms of electrical conductivity (EC) in units of dS/m. Unless stated otherwise, EC can be used in lieu of concentration in calculations presented below. However, EC can overestimate salinity in food processing wastewaters because of degradable conductive organic acids present in the rinse water. The EC due to mineral salts can be estimated by dividing the mineral salinity (in mg/L) of wastewater by 0.64 (Luthin, 1978).

The leaching requirement is based upon maintaining steady state salinity levels in the crop root zone. Equation 4-7 and Equation 4-8 express this:

$$D_w C_w - D_d C_d = 0$$

Equation 4-7. Equation for steady state salt balance.

or

$$D_w EC_w - D_d EC_d = 0$$

Equation 4-8. Equation for steady state electrical conductivity balance.

Where:

D_d = drainage water depth, m

D_w = depth of water applied, m

C_d = concentration of salt in drainage water, mg/L

EC_d = electrical conductivity of drainage water, dS/m.

C_w = concentration of salt in water applied, mg/L

EC_w = electrical conductivity of water applied, dS/m

Note that EC_d is similar to another term found in the literature known as soil water salinity (EC_{sw}) to which the plant root is exposed. As soil dries, the EC_{sw} will increase. EC_d on the other hand will occur only when soil water content at the bottom of the soil profile is at field capacity or higher. An EC meter inserted into the soil (to read EC_{sw}) will only read the same as EC_d when the soil is at field capacity or greater. The similar terms EC_d and EC_{sw} are not to be confused with soil salinity (EC_e) which is salinity measured from a saturated paste extract of a soil, and is used in standard tables (see discussion below) as threshold criteria for crop salinity yield decrements. EC_e helps to standardize EC_{sw} somewhat by saturating the sample before the EC reading.

The first term of Equation 4-7 and Equation 4-8 represents the mass of applied salts and the second term represents the mass of leached salts. The difference of zero indicates that there is neither an increase nor decrease in root zone salinity. These equations assume that other sources and sinks for salts are steady state also (Tanji, 1996), as Equation 4-9 shows:

$$(S_m + S_f) - (S_p + S_c) = 0$$

Equation 4-9. Steady state for salt for sources and sinks.

Where:

S_m = salt dissolved from soil minerals

S_f = salt added from fertilizers or amendments

S_p = salt precipitated in the soil profile

S_c = salt removed by agronomic crops

Equation 4-7 and Equation 4-8 can be rearranged and modified. A simple form of this relationship is presented in Equation 4-10.

$$LR = \frac{D_d}{D_w} = \frac{C_w}{C_d} = \frac{EC_w}{EC_d}$$

Equation 4-10. Leaching requirement calculations.

Where:

LR = leaching requirement, unitless

If Equation 4-10 is solved for C_d, the salt concentration of the drainage is equal to the concentration of the salt in water applied divided by the leaching requirement as presented in Equation 4-11.

$$C_d = \frac{C_w}{LR}$$

Equation 4-11. Concentration of salt in drainage water.

All terms are described above.

The concentration of salt in the applied water (C_w) includes the salt in wastewater, irrigation water, and precipitation. It can be calculated and expressed in terms of electrical conductivity as well as in terms of concentration. C_w (or EC_w) can be calculated as shown in Equation 4-12:

$$C_w = \frac{C_{ww} D_{ww} + C_i D_i + C_r D_r}{D_{ww} + D_i + D_r}$$

Equation 4-12. Concentration of salt in applied water.

Where:

D_{ww} = depth of applied wastewater, m

D_i = depth of applied irrigation water, m

D_r = depth of precipitation, m

C_{ww} = salt concentration in applied wastewater, mg/L (dS/m)

C_i = salt concentration in applied irrigation water, mg/L (dS/m)

C_r = salt concentration in precipitation, mg/L (dS/m)

The leaching requirement can be obtained from Figure 1 of Ayers and Westcot (1985), reproduced here in Figure 4-6. The salinity of the applied water (C_w above, or EC_w in Ayers and Westcott) must be known. The threshold soil salinity (EC_e) for an acceptable yield decrement is found in Table 4-10 (from Ayers and Westcot, 1985). Figure 4-6 is then read from the given EC_w value, straight up until the threshold soil salinity value is reached. The nearest line encountered with its specified leaching requirement (or leaching fraction, LF in the figure) is the LR. If the point is between two lines, an extrapolation between values of the LF of the two lines can be made.

Additional LF lines (0.25, 0.3, 0.5, 0.6, and 0.7) may be plotted by using data from the third column of Table 4-11, the concentration factor 'X'. The equations for additional lines can be derived and subsequently plotted as follows:

$$\text{Salinity of Applied Water} * \text{Concentration Factor} = \text{Soil Salinity}$$

Equation 4-13. Soil Salinity Relationship

Or

$$EC_w * X = EC_e$$

Equation 4-14. Soil Salinity Equation

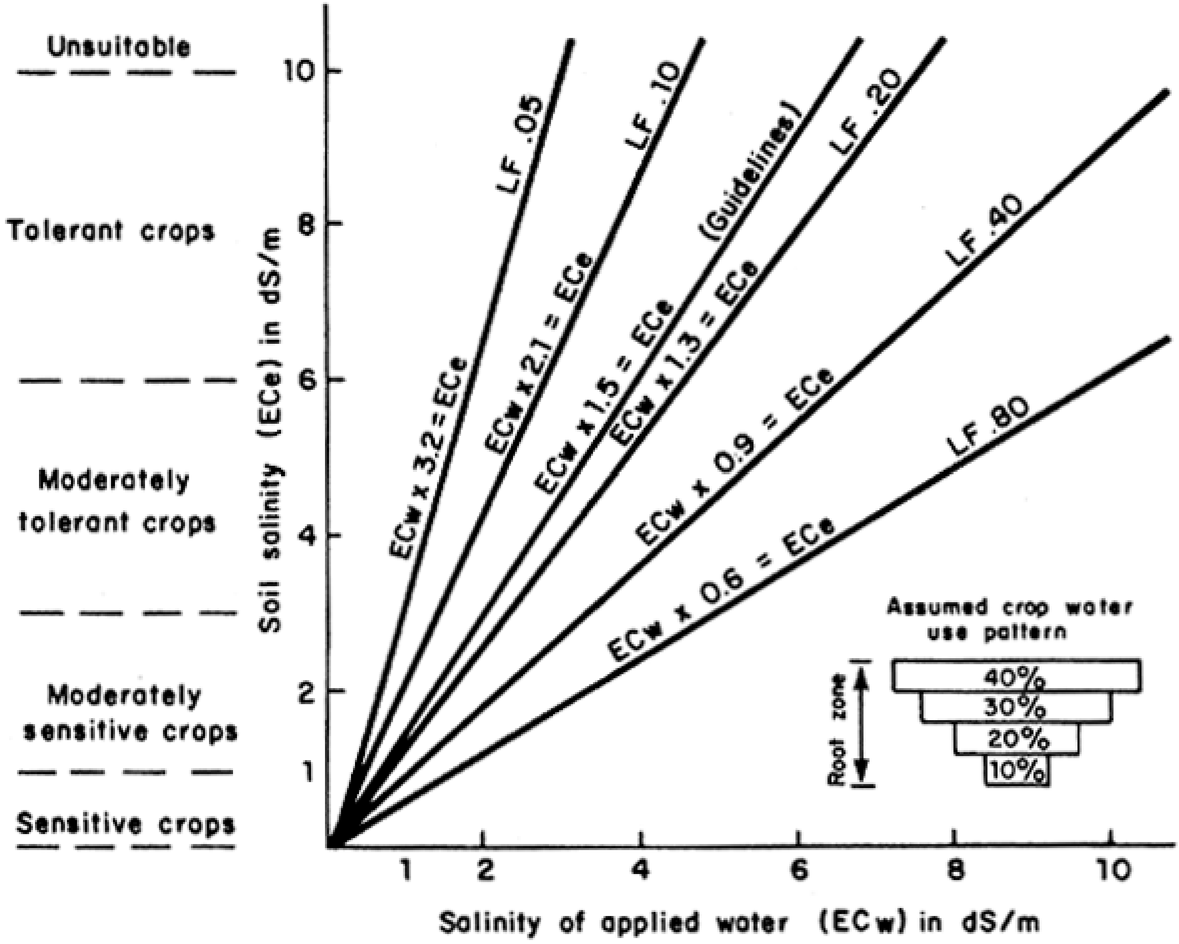


Figure 4-6. Leaching Fraction (Requirement) as Related to Salinity of Applied Water and Soil Salinity (from Ayers and Westcot, 1985).

For example, to find the leaching requirement necessary to obtain a 90% potato yield given an irrigation/wastewater/precipitation composite salinity (EC_w) of 2 dS/m, first find the 90% crop tolerance threshold soil salinity (EC_e) in Table 4-10 (2.5 dS/m). Find 2 dS/m on the x axis of Figure 4-6 and read up until the value 2.5 is reached on the y axis. This point approximately intersects the 0.20 leaching fraction line. This indicates that a leaching requirement of 0.20 would be needed to maintain soil salinity levels below the threshold level.

It should be noted that this calculation is likely conservative, as it assumes that no precipitation of salts occurs in the soil. In general, with the calcareous soils of Idaho, substantial amounts of $CaCO_3$ can precipitate, thereby reducing ECe. See Robbins et al.(1980) and Robbins et al. (1995). More information on soil salinity and salt precipitation is available from the USDA-ARS Kimberly Publications web site:

http://sand.nwisrl.ars.usda.gov/publist.shtml

Another means to estimate the LR can be used. See Rhoades (1974) as cited in Ayers and Westcott (1985). Equation 4-15 should be used for leaching fractions typical of agronomic systems (c. 0.15).

$$\mathrm{LR} = \frac{\mathrm{EC_w}}{5 \cdot \mathrm{EC_e} - \mathrm{EC_w}}$$

Equation 4-15. Leaching requirement formula for LR c. 0.15.

where terms have been defined as previously. The EC_w is entered along with the soil EC_e for the crop at the particular yield decrement threshold desired (0%, 10%, 25% etc.) and the LR is calculated using Equation 4-15, given both the EC_e of the soil and the EC_w of the applied water.

There are important relationships between applied water EC (EC_w), soil water EC (EC_{sw} or EC_d), and soil salinity (EC_e) which apply at typical leaching fractions (c. 0.15) for agronomic systems. Sometimes salinity data is given in certain terms which need to be converted into other terms to be able to use various tables, figures and equations. These relationships are provided as reference:

$$\mathrm{EC_{sw}}\left(or\ EC_d\right) = 3\,\mathrm{EC_w}$$

Equation 4-16. Relationship between soil water and applied water.

$$\mathrm{EC_e} = 1.5\,\mathrm{EC_w}$$

Equation 4-17. Relationship between soil salinity and applied water.

$$\mathrm{EC_{sw}}\ (or\ EC_d) = 2\,\mathrm{EC_e}$$

Equation 4-18. Relationship between soil water and soil salinity.

Table 4-10. Crop tolerance and yield potential of selected crops as influenced by irrigation water salinity (EC_w)[1] or soil salinity (EC_e) yield potential[2].

FIELD CROPS	100%		90%		75%		50%		0% "maximum"[3]	
	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w
Barley *(Hordeum vulgare)*[4]	8.0	5.3	10	6.7	13	8.7	18	12	28	19
Cotton *(Gossypium hirsutum)*	7.7	5.1	9.6	6.4	13	8.4	17	12	27	18
Sugarbeet *(Beta vulgaris)*[5]	7.0	4.7	8.7	5.8	11	7.5	15	10	24	16
Sorghum *(Sorghum bicolor)*	6.8	4.5	7.4	5.0	8.4	5.6	9.9	6.7	13	8.7
Wheat *(Triticum aestivum)*[4],[6]	6.0	4.0	7.4	4.9	9.5	6.3	13	8.7	20	13
Wheat, durum *(Triticum turgidum)*	5.7	3.8	7.6	5.0	10	6.9	15	10	24	16
Soybean *(Glycine max)*	5.0	3.3	5.5	3.7	6.3	4.2	7.5	5.0	10	6.7
Cowpea *(Vigna unguiculata)*	4.9	3.3	5.7	3.8	7.0	4.7	9.1	6.0	13	8.8
Groundnut (Peanut) *(Arachis hypogaea)*	3.2	2.1	3.5	2.4	4.1	2.7	4.9	3.3	6.6	4.4
Rice (paddy) *(Oriza sativa)*	3.0	2.0	3.8	2.6	5.1	3.4	7.2	4.8	11	7.6
Sugarcane *(Saccharum officinarum)*	1.7	1.1	3.4	2.3	5.9	4.0	10	6.8	19	12
Corn (maize) *(Zea mays)*	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7
Flax *(Linum usitatissimum)*	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7
Broadbean *(Vicia faba)*	1.5	1.1	2.6	1.8	4.2	2.0	6.8	4.5	12	8.0
Bean *(Phaseolus vulgaris)*	1.0	0.7	1.5	1.0	2.3	1.5	3.6	2.4	6.3	4.2
VEGETABLE CROPS										
Squash, zucchini (courgette) *(Cucurbita pepo melopepo)*	4.7	3.1	5.8	3.8	7.4	4.9	10	6.7	15	10
Beet, red *(Beta vulgaris)*[5]	4.0	2.7	5.1	3.4	6.8	4.5	9.6	6.4	15	10
Squash, scallop *(Cucurbita pepo melopepo)*	3.2	2.1	3.8	2.6	4.8	3.2	6.3	4.2	9.4	6.3
Broccoli *(Brassica oleracea botrytis)*	2.8	1.9	3.9	2.6	5.5	3.7	8.2	5.5	14	9.1
Tomato *(Lycopersicon esculentum)*	2.5	1.7	3.5	2.3	5.0	3.4	7.6	5.0	13	8.4
Cucumber *(Cucumis sativus)*	2.5	1.7	3.3	2.2	4.4	2.9	6.3	4.2	10	6.8

FIELD CROPS	100%		90%		75%		50%		0% "maximum"[3]	
	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w
Spinach *(Spinacia oleracea)*	2.0	1.3	3.3	2.2	5.3	3.5	8.6	5.7	15	10
Celery *(Apium graveolens)*	1.8	1.2	3.4	2.3	5.8	3.9	9.9	6.6	18	12
Cabbage *(Brassica oleracea capitata)*	1.8	1.2	2.8	1.9	4.4	2.9	7.0	4.6	12	8.1
Potato *(Solanum tuberosum)*	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7
Corn, sweet (maize) *(Zea mays)*	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7
Sweet potato *(Ipomoea batatas)*	1.5	1.0	2.4	1.6	3.8	2.5	6.0	4.0	11	7.1
Pepper *(Capsicum annuum)*	1.5	1.0	2.2	1.5	3.3	2.2	5.1	3.4	8.6	5.8
Lettuce *(Lactuca sativa)*	1.3	0.9	2.1	1.4	3.2	2.1	5.1	3.4	9.0	6.0
Radish *(Raphanus sativus)*	1.2	0.8	2.0	1.3	3.1	2.1	5.0	3.4	8.9	5.9
Onion *(Allium cepa)*	1.2	0.8	1.8	1.2	2.8	1.8	4.3	2.9	7.4	5.0
Carrot *(Daucus carota)*	1.0	0.7	1.7	1.1	2.8	1.9	4.6	3.0	8.1	5.4
Bean *(Phaseolus vulgaris)*	1.0	0.7	1.5	1.0	2.3	1.5	3.6	2.4	6.3	4.2
Turnip *(Brassica rapa)*	0.9	0.6	2.0	1.3	3.7	2.5	6.5	4.3	12	8.0
Wheatgrass, tall *(Agropyron elongatum)*	7.5	5.0	9.9	6.6	13	9.0	19	13	31	21
Wheatgrass, fairway crested *(Agropyron cristatum)*	7.5	5.0	9.0	6.0	11	7.4	15	9.8	22	15
Bermuda grass *(Cynodon dactylon)*[7]	6.9	4.6	8.5	5.6	11	7.2	15	9.8	23	15
Barley (forage) *(Hordeum vulgare)*[4]	6.0	4.0	7.4	4.9	9.5	6.4	13	8.7	20	13
Ryegrass, perennial *(Lolium perenne)*	5.6	3.7	6.9	4.6	8.9	5.9	12	8.1	19	13
Trefoil, narrowleaf birdsfoot[8] *(Lotus corniculatus tenuifolium)*	5.0	3.3	6.0	4.0	7.5	5.0	10	6.7	15	10
Harding grass *(Phalaris tuberosa)*	4.6	3.1	5.9	3.9	7.9	5.3	11	7.4	18	12
Fescue, tall *(Festuca elatior)*	3.9	2.6	5.5	3.6	7.8	5.2	12	7.8	20	13
Wheatgrass, standard crested *(Agropyron sibiricum)*	3.5	2.3	6.0	4.0	9.8	6.5	16	11	28	19
Vetch, common *(Vicia angustifolia)*	3.0	2.0	3.9	2.6	5.3	3.5	7.6	5.0	12	8.1

FIELD CROPS	**100%**		**90%**		**75%**		**50%**		**0% "maximum"**[3]	
	EC_e	**EC_w**	**EC_e**	**EC_w**	**EC_e**	**EC_w**	**EC_e**	**EC_w**	**EC_e**	**EC_w**
Sudan grass *(Sorghum sudanense)*	2.8	1.9	5.1	3.4	8.6	5.7	14	9.6	26	17
Wildrye, beardless *(Elymus triticoides)*	2.7	1.8	4.4	2.9	6.9	4.6	11	7.4	19	13
Cowpea (forage) *(Vigna unguiculata)*	2.5	1.7	3.4	2.3	4.8	3.2	7.1	4.8	12	7.8
Trefoil, big *(Lotus uliginosus)*	2.3	1.5	2.8	1.9	3.6	2.4	4.9	3.3	7.6	5.0
Sesbania *(Sesbania exaltata)*	2.3	1.5	3.7	2.5	5.9	3.9	9.4	6.3	17	11
Sphaerophysa *(Sphaerophysa salsula)*	2.2	1.5	3.6	2.4	5.8	3.8	9.3	6.2	16	11
Alfalfa *(Medicago sativa)*	2.0	1.3	3.4	2.2	5.4	3.6	8.8	5.9	16	10
Lovegrass *(Eragrostis sp.)*[9]	2.0	1.3	3.2	2.1	5.0	3.3	8.0	5.3	14	9.3
Corn (forage) (maize) *(Zea mays)*	1.8	1.2	3.2	2.1	5.2	3.5	8.6	5.7	15	10
Clover, berseem *(Trifolium alexandrinum)*	1.5	1.0	3.2	2.2	5.9	3.9	10	6.8	19	13
Orchard grass *(Dactylis glomerata)*	1.5	1.0	3.1	2.1	5.5	3.7	9.6	6.4	18	12
Foxtail, meadow *(Alopecurus pratensis)*	1.5	1.0	2.5	1.7	4.1	2.7	6.7	4.5	12	7.9
Clover, red *(Trifolium pratense)*	1.5	1.0	2.3	1.6	3.6	2.4	5.7	3.8	9.8	6.6
Clover, alsike *(Trifolium hybridum)*	1.5	1.0	2.3	1.6	3.6	2.4	5.7	3.8	9.8	6.6
Clover, ladino *(Trifolium repens)*	1.5	1.0	2.3	1.6	3.6	2.4	5.7	3.8	9.8	6.6
Clover, strawberry *(Trifolium fragiferum)*	1.5	1.0	2.3	1.6	3.6	2.4	5.7	3.8	9.8	6.6
FRUIT CROPS[10]										
Date palm *(phoenix dactylifera)*	4.0	2.7	6.8	4.5	11	7.3	18	12	32	21
Grapefruit *(Citrus paradisi)*[11]	1.8	1.2	2.4	1.6	3.4	2.2	4.9	3.3	8.0	5.4
Orange *(Citrus sinensis)*	1.7	1.1	2.3	1.6	3.3	2.2	4.8	3.2	8.0	5.3
Peach *(Prunus persica)*	1.7	1.1	2.2	1.5	2.9	1.9	4.1	2.7	6.5	4.3
Apricot *(Prunus armeniaca)*[11]	1.6	1.1	2.0	1.3	2.6	1.8	3.7	2.5	5.8	3.8
Grape *(Vitus sp.)*[11]	1.5	1.0	2.5	1.7	4.1	2.7	6.7	4.5	12	7.9
Almond *(Prunus dulcis)*[11]	1.5	1.0	2.0	1.4	2.8	1.9	4.1	2.8	6.8	4.5

FIELD CROPS	100%		90%		75%		50%		0% "maximum"[3]	
	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w
Plum, prune *(Prunus domestica)*[11]	1.5	1.0	2.1	1.4	2.9	1.9	4.3	2.9	7.1	4.7
Blackberry *(Rubus sp.)*	1.5	1.0	2.0	1.3	2.6	1.8	3.8	2.5	6.0	4.0
Boysenberry *(Rubus ursinus)*	1.5	1.0	2.0	1.3	2.6	1.8	3.8	2.5	6.0	4.0
Strawberry *(Fragaria sp.)*	1.0	0.7	1.3	0.9	1.8	1.2	2.5	1.7	4	2.7

From Ayers and Westcot, 1985[1] Adapted from Maas and Hoffman (1977) and Maas (1984). These data should only serve as a guide to relative tolerances among crops. Absolute tolerances vary depending upon climate, soil conditions and cultural practices. In gypsiferous soils, plants will tolerate about 2 dS/m higher soil salinity (ECe) than indicated but the water salinity (ECw) will remain the same as shown in this table.

[2] ECe means average root zone salinity as measured by electrical conductivity of the saturation extract of the soil, reported in deciSiemens per metre (dS/m) at 25°C. ECw means electrical conductivity of the irrigation water in deciSiemens per metre (dS/m). The relationship between soil salinity and water salinity (ECe = 1.5 ECw) assumes a 15–20 percent leaching fraction and a 40-30-20-10 percent water use pattern for the upper to lower quarters of the root zone. These assumptions were used in developing the guidelines in Table 1.

[3] The zero yield potential or maximum ECe indicates the theoretical soil salinity (ECe) atwhich crop growth ceases.

[4] Barley and wheat are less tolerant during germination and seeding stage; ECe should not exceed 4–5 dS/m in the upper soil during this period.

[5] Beets are more sensitive during germination; ECe should not exceed 3 dS/m in the seeding area for garden beets and sugar beets.

[6] Semi-dwarf, short cultivars may be less tolerant.

[7] Tolerance given is an average of several varieties; Suwannee and Coastal Bermuda grass are about 20 percent more tolerant, while Common and Greenfield Bermuda grass are about 20percent less tolerant.

[8] Broadleaf Birdsfoot Trefoil seems less tolerant than Narrowleaf Birdsfoot Trefoil.

[9] Tolerance given is an average for Boer, Wilman, Sand and Weeping Lovegrass; Lehman Lovegrass seems about 50 percent more tolerant.

[10] These data are applicable when rootstocks are used that do not accumulate Na^+ and Cl^- rapidly or when these ions do not predominate in the soil. If either ions do, refer to the toxicity discussion in Section 4.

[11] Tolerance evaluation is based on tree growth and not on yield.

Table 4-11. Concentration factors (X) for predicting soil salinity (EC_e) from irrigation water salinity (EC_w) and the leaching fraction (LF).

Leaching Fraction (LF)	Applied Water Needed (Percent of ET)	Concentration Factor [2] (X)
0.05	105.3	3.2
0.10	111.1	2.1
0.15	117.6	1.6
0.20	125.0	1.3
0.25	133.3	1.2
0.30	142.9	1.0
0.40	166.7	0.9
0.50	200.0	0.8
0.60	250.0	0.7
0.70	333.3	0.6
0.80	500.0	0.6

From Ayers and Westcot, 1985.

4.4.8 Irrigation Application Efficiencies

Table 4-12. Application efficiencies (expressed as percents) by system type (Ashley et al., 1998).

Typical irrigation system application efficiencies			
Application efficiency			
Surface systems		**Sprinkler systems***	(%)
Furrow	35 - 65	Stationary lateral (wheel or hand move)	60 - 75
Corrugate	30 - 55	Solid set lateral	60 - 85
Border, level	60 - 75	Traveling big gun	55 - 67
Border, graded	55 - 75	Stationary big gun	50 - 60
Flood, wild	15 - 35	High pressure center pivot	65 - 80
Surge	50 - 55	Low pressure center pivot	75 - 85
Cablegation	50 - 55	Moving lateral (linear)	80 - 87
		Micro irrigation systems	
		Surface/subsurface drip	90 - 95
		Micro spray or mist	85 - 90

*For sprinkler systems, lower values should be used for wide nozzle spacing and windy conditions.
Source: Sterling, R. and W.H. Neibling. 1994. Final Report of the Water Conservation Task Force. IDWR Report. Idaho Department of Water Resources, Boise, ID.

4.4.9 Determining Site Specific Non-growing Season Hydraulic Loading Rates (HLR_{ngs})

This section provides guidance on determining non-growing season hydraulic loading rates (HLR_{ngs}). The calculation as presented and explained below is a significant simplification of processes taking place. The rate is designed to generate minimal leaching and is likely environmentally protective. However, the appropriateness of the guideline value obtained must be evaluated on a case-by-case basis, particularly with respect to the timing of wastewater land application during the non-growing season, and cumulative precipitation and evaporation (i.e. the available storage capacity at the time of application). The HLR_{ngs} is defined as follows:

$$HLR_{ngs} = [AWC + E - PPT_{ngs}]$$

Equation 4-19. Non-growing season hydraulic loading rate.

where AWC is the soil's available water holding capacity, E is non-growing season evaporation, and PPT_{ngs} is the non-growing season precipitation. These terms are further described below:

AWC is the available water holding capacity of the soil. AWC for purposes here is typically calculated for a 60 inch soil depth or a root limiting layer, whichever is shallowest. AWC values can be determined site-specifically. More general and readily obtainable values are also available from several sources. Soil AWC information may be found in National Resource Conservation Service (NRCS) Soil Survey Reports. Spatial and aspatial data (including soil AWC) may be down-loaded from the following NRCS Web site:

http://www.ftw.nrcs.usda.gov/ssurgo_ftp3.html

Soil AWC can also be estimated from soil textural properties (Saxton et al. 1986). An automated soil-water characteristics/hydraulic properties calculator has been developed, also by Saxton and others at Washington State University, and is available for download at the following Web site:

http://hydrolab.arsusda.gov/soilwater/Index.htm

Soil AWC, as used in Equation 4-19, is typically based on physical soil properties that do not change, so that a general guideline value may be calculated for inclusion into a permit or plan of operation. There are other factors involving the determination of AWC that are important, but if considered make the HLR_{ngs} a constantly changing value. For example, if the crop's effective rooting depth (i.e. the depth at which the crop roots extract the majority of the water utilized by the plant) is considered, the HLR_{ngs} will change as the crop changes. Table 1 of Ashley et al. (1998) shows effective rooting depths of typical Idaho crops varying between 0.5 feet (e.g. winter grains) and 4 feet (e.g. alfalfa).

If the proportion of the soil's AWC already filled with water at the beginning of the non-growing season is determined, and not assumed to be zero, this will also change the HLR_{ngs} value every year. The expediency of having either a static value or one which annually changes must be weighed against the cost of making measurements, sensitivity of the resource being protected, and usefulness of the information in protecting ground and surface water for each site.

Soils are not actually depleted of plant available water, and, in some cases, may be close to field capacity at the end of the growing season given decreasing ET rates and relatively constant wastewater application rates. Good agronomic practice does not dry a field to the wilting point (15 bar) where crop death results. If the application system is operated year round, it is likely that application rates going into the non-growing season during September and October may exceed the ET during that period, thus the soil water content could likely approach that at field capacity. A soil AWC adjusted for typical end-of-growing-season soil water content (dependant upon typical management practices on a site-specific basis), rather than assuming zero water content, would be a more reasonable assumption, but is not typically how Equation 4-19 is applied. As with guidance in general, site-specific circumstances should determine how best to apply Equation 4-19.

Variability of soils on a hydraulic management unit generally means variable AWC values as well. In some cases, an acreage weighted average AWC may be an appropriate estimate for the unit. In other cases, selecting an AWC from the most limiting soil (e.g. coarse textured soils, shallow soils etc.) of reasonable areal extent may be the more environmentally protective. Such determinations need to be done on a case-by-case basis, particularly with respect to the sensitivity and vulnerability of ground water.

PPT_{ngs} = average precipitation falling during the non-growing season. Sources of precipitation data are provided in Section 4.1.1.2.2. A representative period of record should be used when determining PPT_{ngs}, such as the mean from a thirty-year period from present.

Effective precipitation (PPT_e) should not be used when calculating NGS hydraulic balances. As described in Section 4.1.1.2.2, PPT_e is employed to describe precipitation effective for plant growth, and as such has application only in the growing season. Non-growing season evaporative or evapotranspirative losses, determined as described previously, are reckoned to account for non-leaching and non-runoff precipitation losses in non-growing season hydraulic balance calculations.

E = estimate of evaporation/evapotranspiration during the non-growing season. This guidance provides four sources for E estimates:

Lysimeter measurement of non-growing season ET for the Kimberly area is found in Wright (1991). This is one of the few non-growing season lysimeter ET studies which have been done. Result of this multi-year study are found in Section 4.4.9 (Table 4-14). Plots of averaged ET and precipitation (including a cumulative plot) during the non-growing season are also provided in Figures 4-10 and 4-11. In the cumulative plot (Figure 4-11), cumulative wastewater loading can also be plotted. Both precipitation and wastewater loading plots can be summed to yield a cumulative water loading received. A value equal to the AWC of the soil (preferably the remaining AWC not filled with water at the end of the growing season) can be added to each point of the cumulative ET plot to obtain the cumulative soil storage capacity. So long as the cumulative water loading plot stays below the cumulative soil storage plot, no leaching would take place. The results of Wright (1991) can be utilized for all of Southern Idaho south of Whitebird in valley areas below about 5000 ft. elevation, since winter conditions are not too different across all of southern Idaho for areas near or on the Snake and Boise plains (Allen, 2006).

Non-Averaged NGS ET Data: Non-growing season ET data (for bare wet soil) for different weather stations may be found at the AgriMet Historical Archive Weather Data Access Web Site:

http://www.usbr.gov/pn/agrimet/webarcread.html

These values are calculated using the 1982 Kimberly-Penman Equation as modified in Wright (1996) (Dr. James Wright, Personal Communication; August 20, 2003). Daily ET data for a desired period of record (e.g. a thirty-year period from present) may be down-loaded. In order to obtain historical monthly averages of non-growing season ET, down-loaded data from the period of record may then be summed and averaged by month. Data from a single year of record should not be utilized to determine non-growing season ET. After monthly average values of ET are calculated, they should be multiplied by an 'evaporation coefficient' (or a non-growing season ET coefficient, referred to as a crop coefficient, or K_c, during the growing season) (discussed below) to account for periods of both snow cover and dry soil surface conditions (J. Wright, August 20, 2003).

Averaged ET Data: Averaged summary non-growing season ET data for various periods of record are found in Table 4-13.. These data are from AgriMet summary spreadsheet tables provided by Mr. Peter Palmer of the USBR. These averaged data have been multiplied by an 'evaporation coefficient' of 0.7 .

An evaporation coefficient of 0.7 is recommended by Wright (2003). The evaporation coefficient is derived by calculating monthly ET_r by the Kimberly Penman equation and dividing that into the ET values reported by Wright (1991). Figure 4-7 and Figure 4-8 show the calculated NGS ET coefficients as they vary by month, by year, and by type of cover. A mean value for each month of the NGS could be used. Based on all years data from Wright (1991), a coefficient of 0.6 might be more appropriate and conservative. One consideration to make is that applications by sprinkler during winter time will wet the surface and increase to some degree the coefficient over those derived from Wright (1991). See Allen (2006).

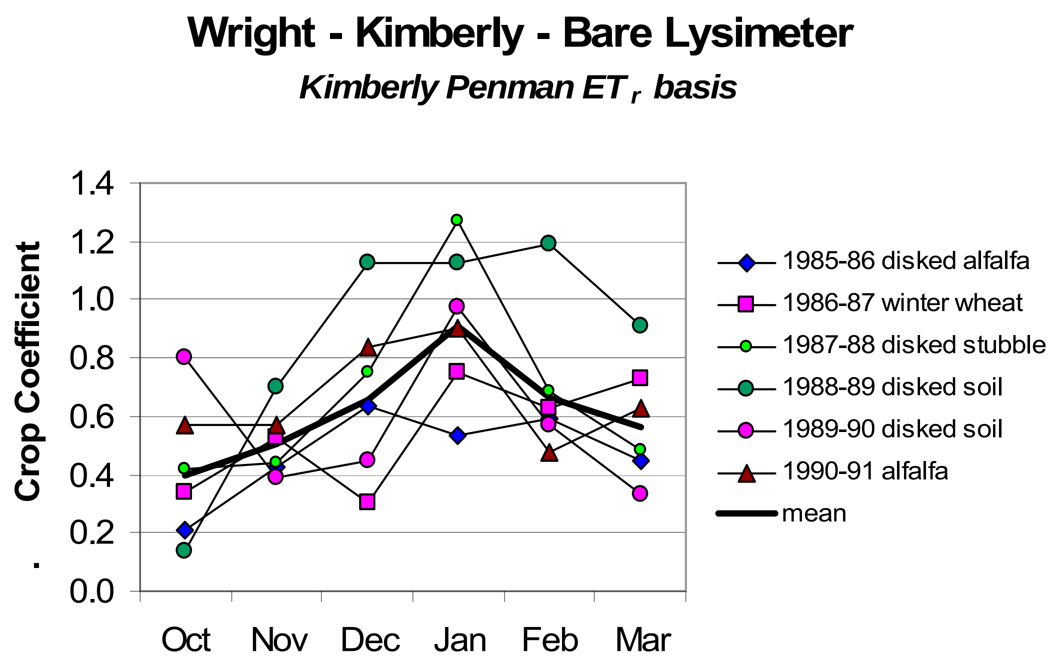


Figure 4-7

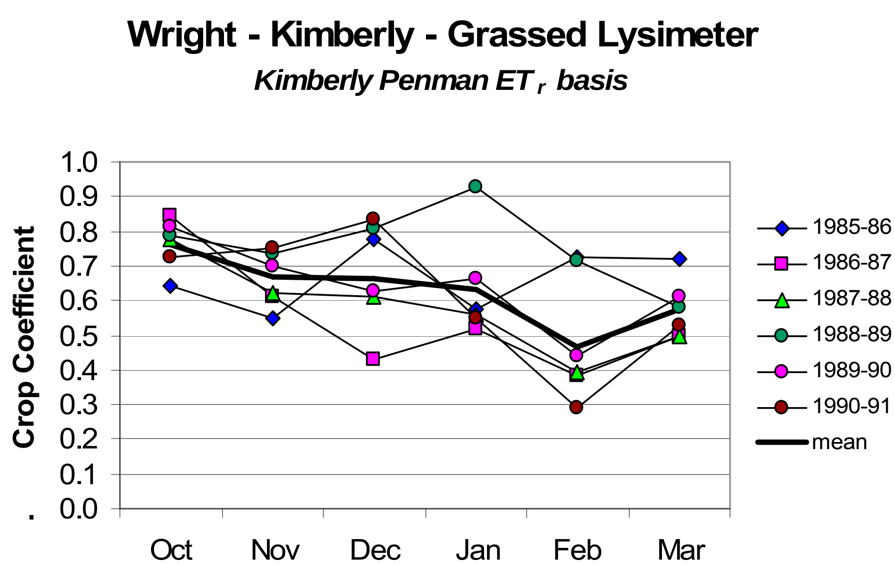


Figure 4-8

Allen (1996) found that, for mountain valley areas with similar climate as Logan UT (Allen, 2006) a coefficient of 0.5 multiplied by the reference grass ET (ET_o) was adequate to predict non-growing season evaporation for days having no snow cover, as Equation 4-20 states:

$$ET_{ngs} = 0.5 \cdot ET_o$$

Equation 4-20. Non-growing season ET.

Agrimet data in Idaho uses alfalfa reference ET (ET_r) as the reference ET rather than ET_o). Wright et al. (2000) provides the following relationship for the conversion of ET_r to ET_o:

$$ET_o = 0.87 \cdot ET_r$$

Equation 4-21. Calculation of ET_o

So, to obtain ET_{ngs} from ET_r, Equation 4-22 may be used (again, for mountain valley areas similar in climate to Logan UT):

$$ET_{ngs} = (0.5) \cdot (0.87) ET_r \quad \text{or } ET_{ngs} = 0.43 \cdot ET_r$$

Equation 4-22. Calculation of ET_{ngs}.

Table 4-13. Non-growing season ET data.

USBR Weather Station Code	Location	Units - All Entries are Inches							Totals				Period of Record
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	Oct -> April	Oct -> Mar	Nov -> April	Nov -> Mar	
ABEI	Aberdeen, ID	2.4	0.8	0.4	0.4	0.8	1.9	3.1	9.8	6.7	7.4	4.3	' 91 - ' 02
AFTY	Afton, WY	1.8	0.6	0.2	0.3	0.6	1.4	2.4	7.2	4.8	5.4	3.0	' 87 - ' 02
AHTI	Ashton, ID	2.3	0.8	0.4	0.4	0.8	1.6	2.7	8.8	6.2	6.6	3.9	' 87 - ' 02
BOII	Boise, ID	1.6	0.7	0.4	0.4	0.8	1.7	2.7	8.4	5.7	6.7	4.0	' 95 - ' 02
FAFI	Fairfield, ID	2.4	0.8	0.3	0.4	0.7	1.6	2.8	9.0	6.2	6.7	3.8	' 87 - ' 02
FTHI	Fort Hall, ID	2.6	0.9	0.4	0.4	0.7	1.8	3.3	10.1	6.8	7.5	4.2	' 01 - ' 02
GDVI	Grandview, ID	2.3	1.0	0.5	0.5	1.0	2.1	3.2	10.7	7.5	8.4	5.2	' 93 - ' 02
GFRI	Glenns Ferry, ID	2.8	1.2	0.5	0.6	1.0	2.2	3.1	11.4	8.2	8.6	5.4	' 93 - ' 02
KTBI	Kettle Butte, ID	2.5	0.8	0.2	0.3	0.6	1.7	2.9	9.0	6.1	6.5	3.6	' 96 - ' 02
MALI	Malta, ID	2.7	1.2	0.6	0.7	1.1	2.1	3.3	11.6	8.3	8.9	5.7	' 90 - ' 02
MNTI	Monteview, ID	2.0	0.7	0.2	0.2	0.5	1.6	2.9	8.1	5.2	6.2	3.3	' 96 - ' 02
NMPI	Nampa, ID	2.6	1.1	0.5	0.5	1.0	2.3	3.3	11.4	8.0	8.7	5.4	' 96 - ' 02
ONTO	Ontario, OR	2.4	0.8	0.4	0.4	0.8	2.0	3.3	10.0	6.7	7.7	4.4	' 92 - ' 02
PICI	Picabo, ID	2.2	0.8	0.9	0.4	0.8	1.7	2.9	9.7	6.8	7.5	4.6	' 93 - ' 02
PMAI	Parma, ID	2.3	0.9	0.5	0.4	0.9	2.2	3.4	10.5	7.1	8.3	4.9	' 86 - ' 02
RPTI	Rupert, ID	2.5	1.0	0.5	0.6	0.9	2.0	3.2	10.7	7.5	8.3	5.1	' 88 - ' 02
RXGI	Rexburg, ID	2.1	0.7	0.3	0.3	0.7	1.7	2.9	8.6	5.7	6.5	3.6	' 87 - ' 02
TWFI	Twin Falls, ID	2.6	1.1	0.6	0.7	1.0	2.2	3.2	11.4	8.1	8.7	5.5	' 90 - ' 02

Another approach to estimating the K_c during the nongrowing season is to use the 'initial K_c' procedure from FAO-56 (Allen et al., 1998) where the K_c estimate is a function of wetting frequency and ET_o rate, as Figure 4-9shows. The benefit of this method is that the $K_{c\ ngs}$ increases with increased wetting frequency. The graph is described in detail in Chapter 5 of

Allen et al. (1998; pages 114-119) and the application of the graph for nongrowing periods is described in Chapter 11 of Allen et al. (1998; pages 207 – 210).[3]

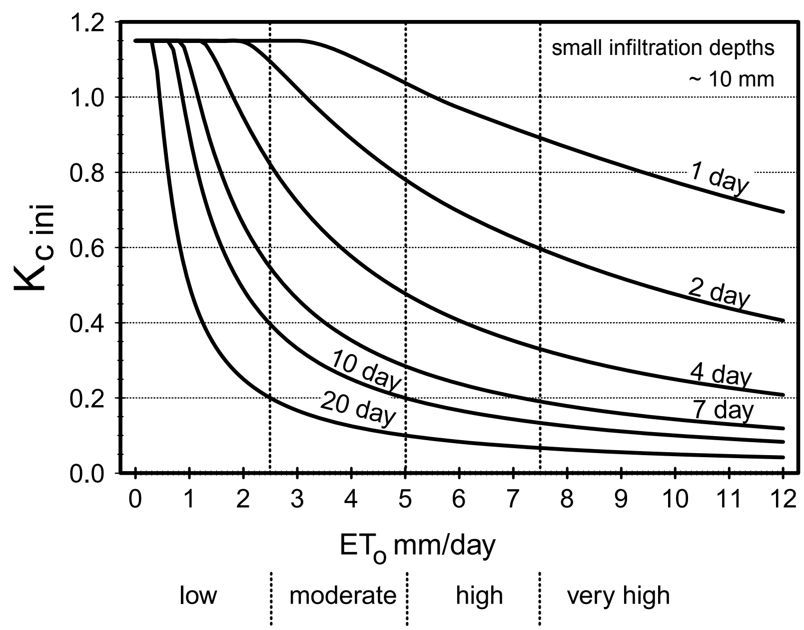


Figure 4-9. ET Crop coefficients as a function of ET_0 (Grass Reference ET) and frequency of soil wetting.

Figure 4-9 shows the average K_c during the nongrowing season (= $K_{c\ ini}$) as related to the level of ET_o and the interval between irrigations and/or significant rain during the period when wetting events are relatively light (about 10 mm per event) (from Allen et al. 1998).

For example, if the month of November has an average ET_o = 2 mm/day and the irrigation frequency of a land application system is every 7 days, then the $K_{c\ ngs}$ from is about 0.6 and the ET_{ngs} = 0.6 (2) = 1.2 mm/day or 36 mm for the month. Since reference ET data is in terms of ET_r, ET data will have to be converted from ET_r to ET_o by using Equation 4-19 before using the method in this figure.

A leaching requirement/leaching fraction was included in previous editions of the Guidance (see definition in Section 4.1.1.2.2). It is generally observed that soil EC levels from wastewater land treatment sites in Idaho seldom show increases over time, which would indicate salt build-up. Soil EC levels usually reflect agronomically acceptable ranges (i.e. salt loading insufficient to cause crop yield decrements). Apparently there is sufficient leaching taking place, both through normal agronomic practices employed at wastewater land treatment sites, and at sites practicing non-growing season application to provide the leaching fraction necessary for the control of salt build-up. DEQ would allow the inclusion of additional leaching fraction in the event soil EC data indicate salt build-up. Whether the leaching fraction is allowed in the growing or non-growing

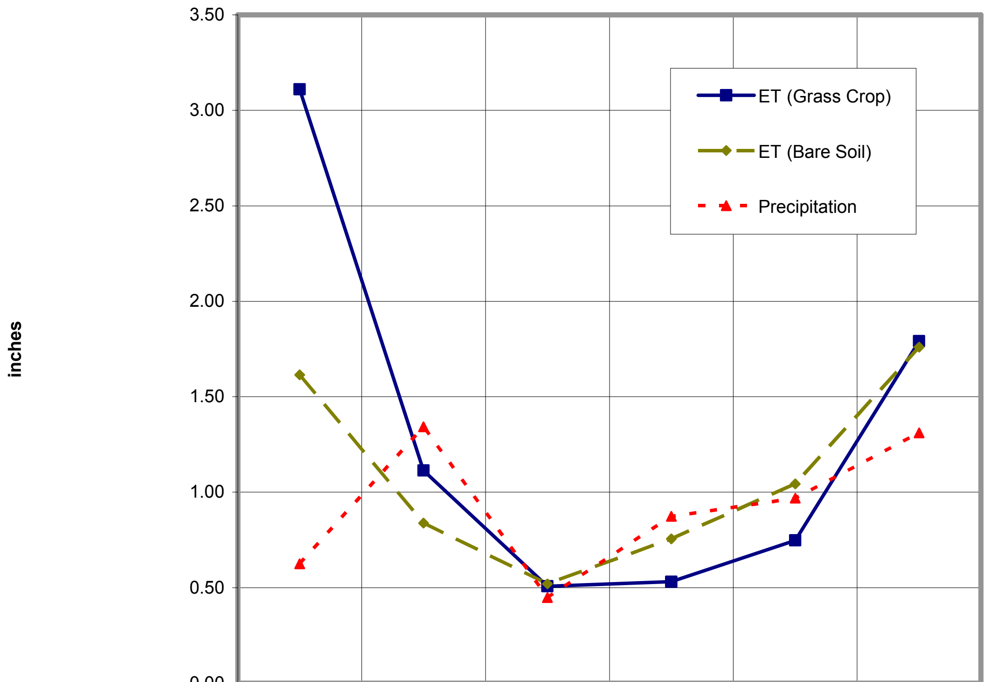
[3] FAO-56 is available on-line at http://www.kimberly.uidaho.edu/water/fao56/index.html and at http://www.fao.org/docrep/X0490E/X0490E00.htm

season would be determined by characterizing potential environmental impacts from either scenario. Leaching requirement calculations are discussed in Section 4.4.7.

4.4.10 Non-Growing Season Lysimeter Evaporation Data

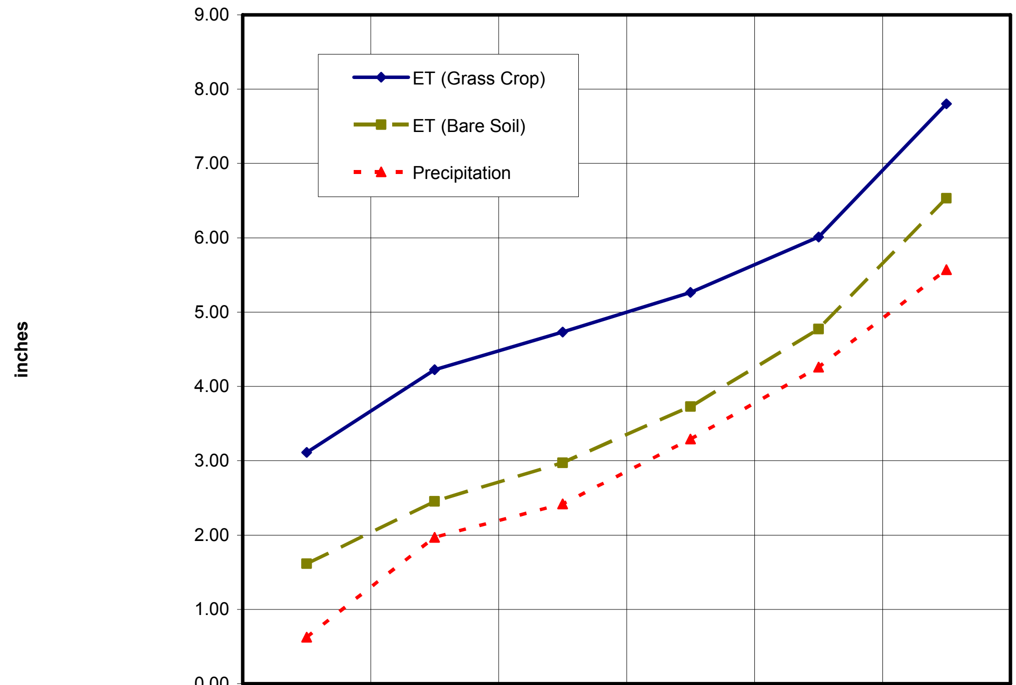
Table 4-14. Lysimeter measurement of non-growing season ET for the Kimberly, ID area.

Year	Total (in)						
	Oct	Nov	Dec	Jan	Feb	Mar	Total
Lysimeter 1 (Grass Crop)							
1985-86	2.52	0.71	0.43	0.59	1.06	2.48	7.80
1986-87	2.95	1.18	0.39	0.35	0.55	1.50	6.97
1987-88	3.58	0.94	0.51	0.43	0.79	1.65	7.91
1988-89	3.78	0.91	0.51	0.75	0.83	1.34	8.15
1989-90	2.64	1.26	0.55	0.59	0.67	2.17	7.87
1990-91	3.19	1.61	0.71	0.43	0.55	1.61	8.07
Mean	3.11	1.11	0.51	0.53	0.75	1.79	7.80
Daily	0.10	0.04	0.02	0.02	0.03	0.06	0.04
Lysimeter 2 (Bare Soil)							
1985-86	0.83	0.55	0.35	0.55	0.87	1.54	4.65
1986-87	1.18	1.02	0.28	0.51	0.91	2.20	6.10
1987-88	1.93	0.67	0.63	0.98	1.38	1.61	7.24
1988-89	0.67	0.87	0.71	0.91	1.38	2.09	6.61
1989-90	2.60	0.71	0.39	0.87	0.87	1.18	6.57
1990-91	2.52	1.22	0.71	0.71	0.91	1.93	8.03
Mean	1.61	0.84	0.52	0.76	1.04	1.76	6.53
Daily	0.05	0.03	0.02	0.02	0.04	0.06	0.04
Precipitation							
1985-86	0.94	1.89	0.79	1.02	3.94	0.67	9.25
1986-87	1.02	0.59	0.08	1.30	0.94	1.46	5.39
1987-88	0.04	1.02	1.14	0.83	0.12	0.83	3.98
1988-89	0.00	3.03	0.00	0.20	0.39	2.56	6.18
1989-90	1.42	1.10	0.04	1.26	0.12	0.98	4.92
1990-91	0.31	0.55	0.67	0.67	0.28	1.38	3.82
Mean	0.63	1.34	0.45	0.87	0.97	1.31	5.59
Daily	0.02	0.05	0.02	0.03	0.04	0.04	0.03



	Oct	Nov	Dec	Jan	Feb	Mar
ET (Grass Crop)	3.11	1.11	0.51	0.53	0.75	1.79
ET (Bare Soil)	1.61	0.84	0.52	0.76	1.04	1.76
Precipitation	0.63	1.34	0.45	0.87	0.97	1.31

Figure 4-10. Plot of monthly non-growing season evaporation/evapotranspiration and precipitation from lysimeter studies in Kimberley Idaho (Wright 1991).



	Oct	Nov	Dec	Jan	Feb	Mar
ET (Grass Crop)	3.11	4.22	4.73	5.26	6.01	7.80
ET (Bare Soil)	1.61	2.45	2.97	3.73	4.77	6.53
Precipitation	0.63	1.97	2.42	3.29	4.26	5.57

Figure 4-11. Plot of cumulative monthly non-growing season evaporation/evapotranspiration and precipitation from lysimeter studies in Kimberley Idaho (Wright 1991).

4.4.11 Non-Growing Season Ground Water Impact Screening Tool for Low-Strength Wastewater Loading

The purpose of this screening tool spreadsheet is to provide a preliminary screening tool for low-strength wastewater applied during the non-growing season (NGS). The screening tool determines worse case increases in ground water nitrate-N concentrations and provides an estimate of an acceptable NGS hydraulic loading rate when change to groundwater is determined to be acceptable.

The screening tool is designed to be simple, conservative, and focused on potential ground water impacts from non-growing season wastewater application. It is meant to provide preliminary information on the feasibility of non-growing season wastewater loading, and is not meant to take the place of more sophisticated modeling which can, and should, be done, depending upon the results of initial screening. Examples of low strength wastewater may include Class A or B municipal reclaimed wastewater, or other industrial or municipal wastewaters with sufficiently low nitrogen, COD, or other constituent concentrations (see further discussion below).

Most of the inputs are relatively straightforward, such as wastewater volumes and concentrations, site dimensions, and meteorological data. The hydrogeologic scenario is critical in estimating changes in ground water nitrate-N concentrations. Therefore, estimates of aquifer parameters should be made by persons having professional expertise in hydrogeology.

There are several simplifying assumptions made in the Non-growing Season Wastewater Loading-Ground Water Screening Tool so that it can serve as a user-friendly screening tool. These are itemized below:

1) The land treatment site is assumed to have a rectangular shape, the length of which is oriented along the ground water flow path. The width is perpendicular to ground water flow. Various length to width ratios can be selected from the spreadsheet.
2) Nitrogen application during the non-growing season is the primary constituent of concern. Other constituents such as TDS or chloride, and their respective changes to ground water concentration during the non-growing season, can also be modeled with this tool. Denitrification/volatilization losses (see below) for other constituents would be set to zero.
3) Rate of denitrification/volatilization losses of NGS applied N can be entered as a proportion in the spreadsheet.
4) In the case of nitrogen, the remainder of the nitrogen applied is conservatively assumed to mineralize, nitrify and leach as nitrate-N.
5) The non-growing season percolate volume is calculated by summing NGS precipitation and wastewater application, and subtracting NGS evaporation (here, Agrimet averaged data with an evaporation coefficient applied).
6) It is assumed that there is no change in either soil water content or soil nitrogen (or other constituent) content from beginning to end of the NGS. Thus, soil storage is not considered in this screening tool for the water balance/percolate calculations. Further site-specific analyses can be done to incorporate the soil AWC parameter, including end-of-growing-season soil moisture, crop type and rooting depth. It should be noted however, that such analyses progress beyond that of ‘screening’.

7) NGS percolate is mixed with NGS groundwater flow beyond the down gradient cross-sectional discharge boundary at a given background concentration to determine a steady state mixed concentration accounting for only NGS activities. The purpose of this analysis is to isolate environmental influence from NGS wastewater application only.
8) Growing season ground water impacts are assumed for the growing season. Leaching rate is assumed and added to volume of groundwater discharging from the down gradient boundary during the growing season only. This combined volume of ground water and percolate has the assumed impacted ground water concentration.
9) It is assumed that normal agronomic management and nutrient and hydraulic loading are being practiced during the growing season. It is also assumed that fertility guides which use soil monitoring are being utilized so that resident soil nutrients in the spring are used for crop growth, and that appropriate nutrient loading is practiced for the particular crop, location and yield goal.
10) A low NGS wastewater COD loading threshold rate for use of this screening tool should be employed in order to reasonably rule out impacts from solubilization of redox sensitive species such as Fe and Mn.
11) Potential growing season and non-growing season ground water impacts, calculated separately, are combined to arrive at predicted impacts for the entire system. The combined volume of percolate and ground water generated/discharged during the NGS (at its calculated constituent concentration), is mixed with the combined volume of percolate and ground water generated/discharged during the GS (at its assumed constituent concentration), to arrive at an estimate of ground water impacts from the system.

Use of the screening tool is straightforward. Input cells are grouped together in the top half of the spreadsheet (Figure 4-12) and are in red font. Site-specific inputs are made there. All other cells, including calculated cells, are in black font and are not to be changed. Calculated cells, provide various results such as leachate volume, concentration etc. The calculated cell at the bottom of the spreadsheet yields the estimated steady-state down-gradient ground water concentration (C_{mix}) of the entire system (i.e. from both growing and non-growing seasons).

The chart provided in the spreadsheet (Figure 4-13) automatically plots C_{mix} as a function of the aquifer hydraulic conductivity within reasonable ranges for the purpose of sensitivity analysis for the parameter which is most likely the least known of the input parameters. In this example, C_{mix} varies from 2.3 mg/L to 2.9 mg/L nitrate-N as hydraulic conductivity varies from 2000 ft/day to 5000 ft/day. This sensitivity analysis is important to do because there are instances where impacts may vary from being of little regulatory concern to being of significant regulatory concern depending on parameter values input in the model. The output of the model, $C_{mix,}$ can then be compared to relevant program guidance to determine the acceptability of the range of predicted ground water impacts, and permitting decisions can be made from there.

There should be no need for the user of the screening tool spreadsheet to access any worksheet other than ‘INPUTS’. There are several other worksheets which contain precipitation and evaporation/evapotranspiration data, lookup tables for area and season-specific date, mixing and dispersion calculations, and data plot files. These other worksheets are automatically invoked to do necessary calculations which appear also in the ‘INPUTS’ worksheet..

Ground Water Impact Mixing Analysis Screening Tool

Non-Growing Season Wastewater Loading
Revision 1/4/2006

Inputs	Parameter Ent	Units	Comments
COD Wastewater Conc (NGS)	20.0	mg/L	
Nitrogen Wastewater Conc. (NGS)	30.0	mg/L	
NGS Wastewater Applied	10	in/acre	
Site Acreage	100	acres	
Non-Growing Season Length	A. Oct - April		
Ratio of Site Length (along GW Flowpath) to Site Width	2:1		Orient rectangle along GW flow path
Climate Station (label cell)	Boise Wsfo		
Agri Met Weather Station (label cell)	Boise, ID		
Aquifer Hydraulic Conductivity (lower range value)	1750	feet/day	
Aquifer Hydraulic Conductivity (higher range value)	5250	feet/day	
Aquifer Hydraulic Gradient	0.0014	unitless	
Aquifer Thickness (not Mixing Depth)	850	feet	
Up Gradient Ground Water Concentration	1.5	mg/L	
Denitrification/Volatilization Losses	0.15	unitless	Recommend <= 0.15
Assumed impacts from Growing Season			
Constituent increase above ambient GW ->	0.5	mg/L	Assume 0.5 - 1.0 mg/L
Estimated leaching in GS ->	1.0	inches	Assume 10% of IWR for Leaching Fraction

Outputs	Calculation Results	Units	
COD Loading NGS	0.3	lb/ac-day	Should be Less than 5 lb/ac-day
Nitrogen Loading NGS	67.9	lb/ac	
NGS Leaching	14.6	inches	
Nitrogen Loss to Leaching	57.7	lb/ac	
Percolate N Concentration	17.5	mg/L	
Flow Path Length	2952	feet	
Predicted Down Gradient GW Nitrate-N Concentration due	3.5	mg/L	
Kh increment for plotting	350	ft/day	
Combined GS and NGS GW Impacts to System			
Cmix gs	2.0	mg/L	
Cmix ngs	3.5	mg/L	
Qngs = Qp + Qgw (MG/season)	317.4	MG	
Qgs = Qp + Qgw (MG/season)	203.2	MG	
Cmix of system (at low range Kh)	2.9	mg/L	

Figure 4-12. Example input and output sheet of the screening tool.

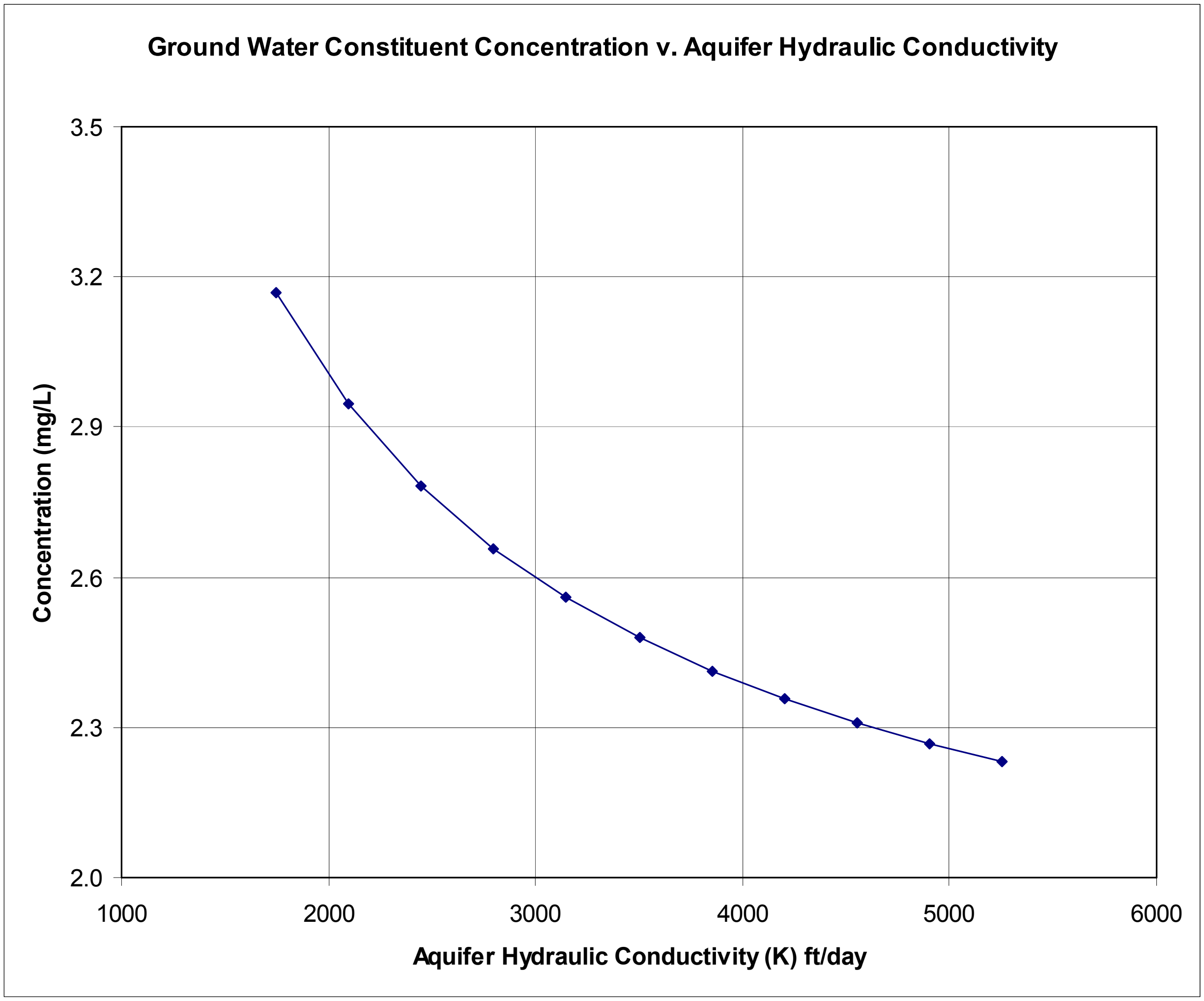


Figure 4-13. Example of sensitivity analysis plot automatically created in the screening tool.

4.4.12 Isopluvials of Precipitation for Runoff Control Design

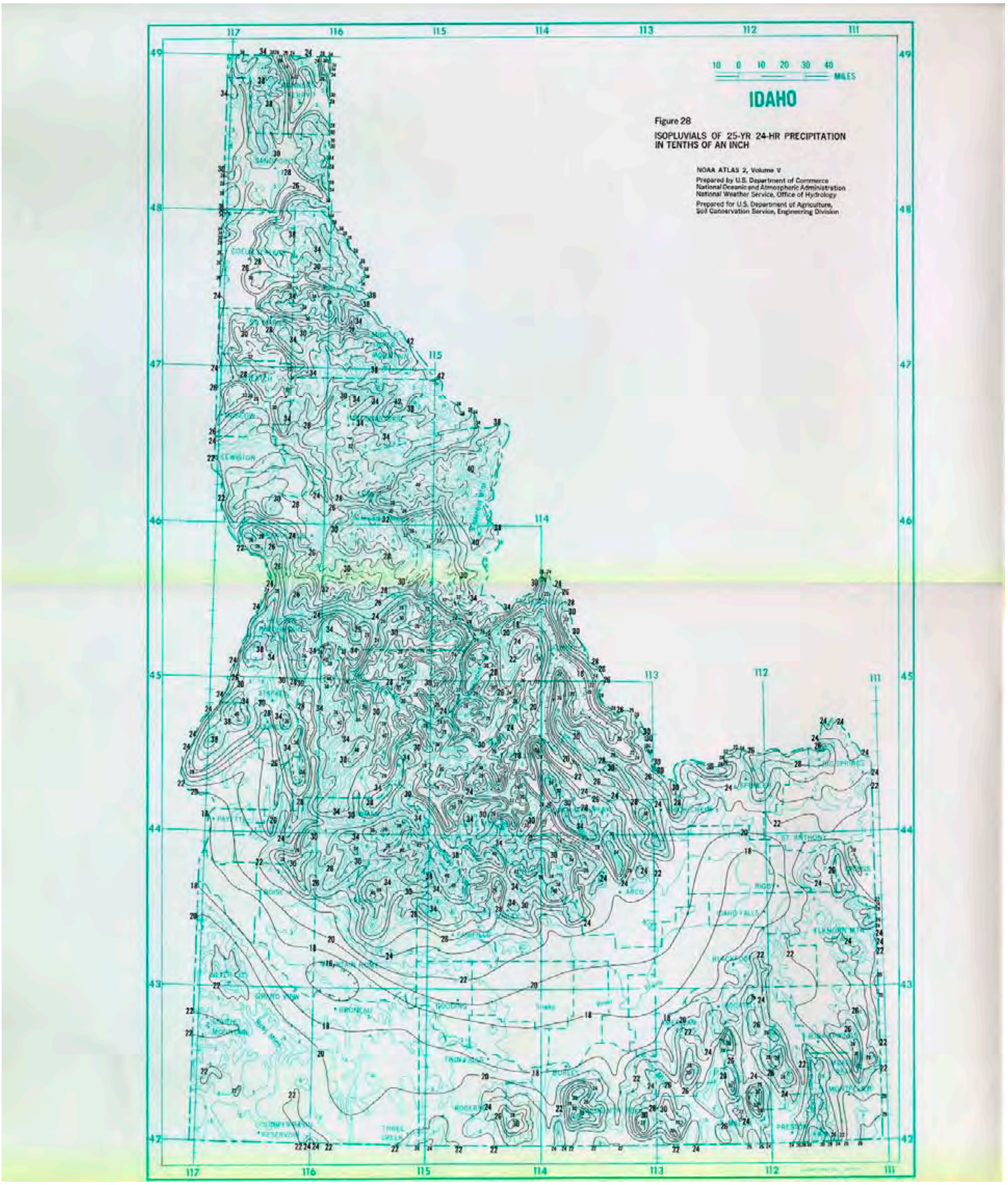


Figure 4-14. 25 year, 24 hour isopluvials.

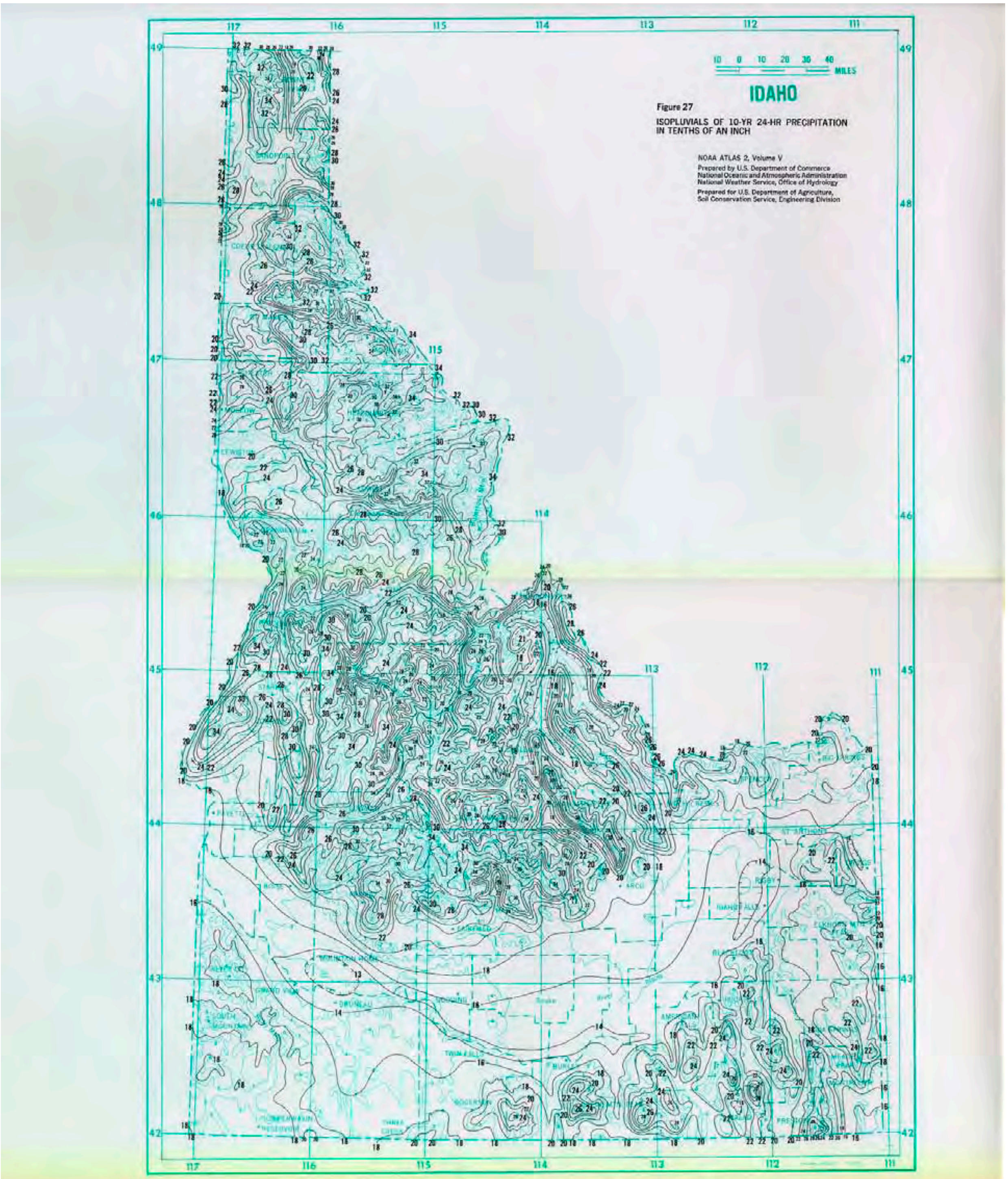


Figure 4-15. 10 year, 24 hour isopluvials.

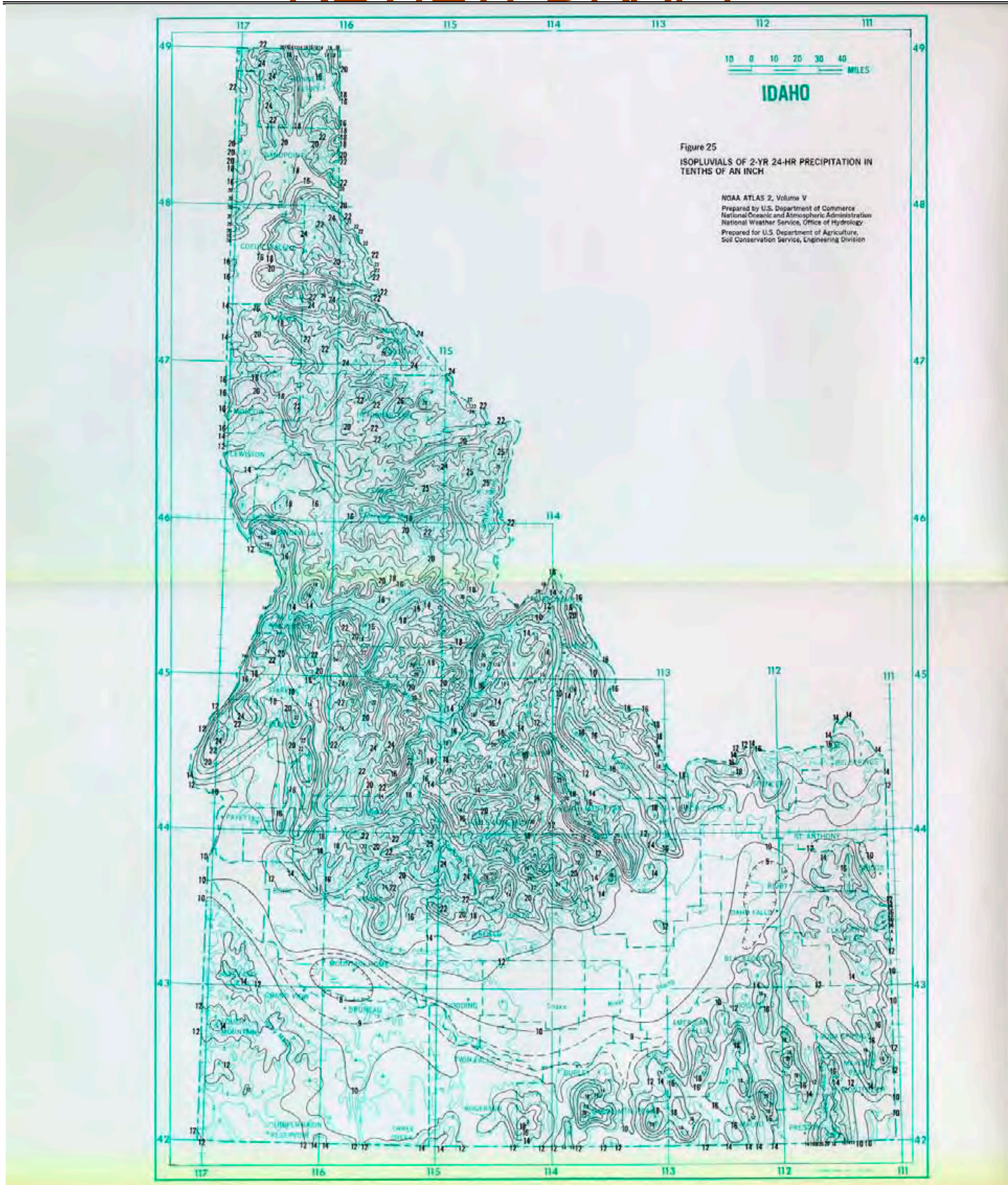


Figure 4-16. 2 year, 24 hour isopluvials.

4.4.13 Determining Appropriate Wastewater Flows to Apply to Chemical Analytical Data for Constituent Loading Calculations

There are several methods, ranging from simple to complex, which may be used to calculate constituent loading rate from constituent concentration data and flow data. These are summarized in Section 4.2.1.5, and are discussed in more detail here. More complex methodologies characterize loading more accurately than simple methods, but involve more sampling and effort in performing calculations.

In the case where a facility samples once during the regulatory sampling period, the concentration of that sample may be applied to the flow during the regulatory sampling period and acres applied to in order to obtain the constituent loading.

In the case where a facility samples more than once during the regulatory sampling period, the concentrations of those samples may be arithmetically averaged and the average applied to the flow during the regulatory sampling period and acres applied to in order to obtain the constituent loading.

In certain cases, characterizing temporal variability of wastewater quality and loading in more detail is very critical for environmental protection. A more accurate way to characterize constituent loading in those cases where a facility finds it necessary to take more than one sample during the regulatory sample period, samples can be associated with, and represent flows in the following manner:

The first sample represents flow from 12:00 am on the first day of the regulatory sampling period (i.e. month, week, etc.) until half-way in time between the first and second samples to the nearest day. If there are an odd number of days between two samples, apply the middle day of flow to the earlier sample.

The second sample represents flow from half-way in time between the first and second samples until half-way in time between the second and third samples to the nearest day, and so forth through the regulatory sample period. The last sample, however, represents flow from half-way in time between the second to the last sample and the last sample until 11:59 pm of the last day of the regulatory sampling period.

Example 2 in Section 4.4.14.1 illustrates how the constituent loading rate would be calculated from daily flows, a required monthly sample taken in the middle of the month, and three additional samples taken during the month. Sample #1 represents flow from 12:00 am on the first day of the regulatory sampling period (November 1) until half-way in time between Sample #1 and Sample #2 (November 11). Note: Since there are an odd number of days between the two samples, the middle day of flow (November 11) is applied to Sample #1.

Continuing with the example, Sample #2 (the required sample) represents flow from half-way in time between Samples #1 and #2 (November 12) until half-way in time between Samples #2 and #3 (November 17). Sample #3 represents flow from half-way in time between Samples #2 and #3 (November 18) until half-way in time between Samples #3 and #4 (November 23). Sample #4 represents flow from half-way in time between Samples #3 and #4 (November 24) until 11:59 pm of November 30, the last day of the regulatory sampling period.

Example 3 in Section 4.4.14.1 illustrates how the constituent loading rate would be calculated from daily flows, a required weekly sample taken in the middle of the week, and two additional samples taken during the week. Sample #1 represents flow from 12:00 am on the first day of the regulatory sampling period (Sunday) until half-way in time between Sample #1 and Sample #2 (11:59 pm Tuesday). Note: Since there are an odd number of days between the two samples, the middle day of flow (Tuesday) is applied to Sample #1.

Continuing with Example 3, Sample #2 (the required sample) represents flow from half-way in time between Samples #1 and #2 (12:00 am Wednesday) until half-way in time between Samples #2 and #3 (11:59 pm Thursday). Sample #3 represents flow from half-way in time between Samples #2 and #3 (12:00 am Friday) until 11:59 pm Saturday, the last day of the regulatory sampling period.

Example 4 (Section 4.4.13.1.4) is similar to Example 2, but is simpler to calculate, and it is far simpler to write computer code to do the calculation. Multiply the sample concentration by the particular flow measured for that day for each sample taken. Then sum these products. Then take the sum of the products and divide by the sum of the flows for those days samples were collected. This will yield a flow-weighted average concentration for those days on which sampling took place. Then apply this flow-weighted concentration to the sum of all flows in the month (or other sampling period) as described in Section 4.4.13.1.4 to obtain the constituent loading rate.

Yet another method is simply to arithmetically average all sample concentration data, and then utilize total flow for a given regulatory interval. Applying this method to Example #2 data yields the following:

$$\left[\frac{(2500+2200+1800+2000)}{4}\right] \ {}^{mg}\!/\!{}_{L} * \ 7.20MG \ * \ 8.34 \ {}^{lb}\!/\!{}_{MG} \ * \ \frac{1}{100 \ \ ac} = 1280\,{}^{lb}\!/\!{}_{ac}$$

4.4.13.1 Example Calculations

This section presents three examples showing how loading rates are calculated based upon the regulatory sampling period, number of samples, flow, and sample concentration of chemical oxygen demand (COD).

Note that these examples calculate loading rates for the regulatory sampling period (month or week. Both the loading rate, as well as the loading limit, for COD are typically expressed in lb/acre-day based upon a seasonal average. Thus, monthly or weekly COD loading rates calculated above would be summed for the particular season (growing season/non-growing season), and that sum divided by the number of days in the particular season.

4.4.13.1.1 Example #1

One Required Sample for the Regulatory Sample Period (Month)

Month of November. HMU MU-0999-01 (100 acres)

Table 4-15. Data for Example 1.

Wastewater Sample Date and Time	Daily Flows (MG)	Sample Concentration of COD (mg/L)	Notes
1	0.10		12:00 am November 1st is the beginning of the Regulatory Sampling Period
2	0.20		
3	0.50		
4	0.30		
5	0.60		
6	0.40		
7	0.30		
8	0.30		
9	0.00		
10	0.20		
11	0.20		
12	0.10		
13	0.30		
14 Permit Required Sample Taken	0.20	2500	Apply this concentration to Regulatory Sampling Period
15	0.20		
16	0.10		
17	0.10		
18	0.20		
19	0.30		
20	0.60		
21	0.30		
22	0.10		
23	0.10		
24	0.00		
25	0.30		
26	0.40		
27	0.40		
28	0.20		
29	0.10		
30	0.10		11:59 pm November 30th is the end of the Regulatory Sample Period
31	-		
Total Flow For Month	7.20		

Monthly loading is (2500 mg/L * 7.2 MG * 8.34 lb/MG) / 100 acres = 1501 lb/acre.

4.4.13.1.2 Example #2:

One Required Sample for the Regulatory Sample Period (Month) Plus Three Additional Samples. Month of November. HMU MU-0999-01 (100 acres)

Table 4-16. Data for Example 2.

Wastewater Sample Date and Time	Daily Flows (MG)	Sample Concentration of COD (mg/L)	Notes
1	0.10		12:00 am November 1st is the beginning of the Regulatory Sampling Period and of time interval 1
2	0.20		
3	0.50		
4	0.30		
5	0.60		
6	0.40		
7	0.30		
Additional Sample Taken (Sample 1)	0.30	2500	Apply this concentration to time interval 1
9	0.00		
10	0.20		
11	0.20		11:59 pm November 11th is upper time bound for time interval 1
12	0.10		12:00 am November 12th is lower time bound for time interval 2
13	0.30		
Permit Required Sample Taken (Sample 2)	0.20	2200	Apply this concentration to time interval 2
15	0.20		
16	0.10		
17	0.10		11:59 pm November 17th is upper time bound for time interval 2
18	0.20		12:00 am November 18th is lower time bound for time interval 3
19	0.30		
20	0.60		
Additional Sample Taken (Sample 3)	0.30	1800	Apply this concentration to time interval 3
22	0.10		
23	0.10		11:59 pm November 23rd is upper time bound for time interval 3
24	0.00		12:00 am November 24th is lower time bound for time interval 4
25	0.30		
Additional Sample Taken (Sample 4)	0.40	2000	Apply this concentration to time interval 4
27	0.40		
28	0.20		
29	0.10		
30	0.10		11:59 pm November 30th is the end of the Regulatory Sample Period and time interval 4
31	-		
Total Flow for Month	7.20		

Flow for time interval 1 is 3.10 MG. Interval 1 loading is (2500 mg/L * 3.10 MG * 8.34 lb/MG) / 100 acres = 646 b/acre.

Flow for time interval 2 is 1.00 MG. Interval 2 loading is (2200 mg/L * 1.00 MG * 8.34 lb/MG) / 100 acres = 183 lb/acre.

Flow for time interval 3 is 1.60 MG. Interval 3 loading is (1800 mg/L * 1.60 MG * 8.34 lb/MG) / 100 acres = 240 lb/acre.

Flow for time interval 4 is 1.50 MG. Interval 4 loading is (2000 mg/L * 1.50 MG * 8.34 lb/MG) / 100 acres = 250 lb/acre

TOTAL Loading for the Month = 1320 lb/acre

4.4.13.1.3 Example #3:

One Required Sample for the Regulatory Sample Period (Week) Plus Two Additional Samples. Month of November. HMU MU-0999-01 (100 acres)

Table 4-17. Data for Example 3.

Wastewater Sample Date and Time	Daily Flows (MG)	Sample Concentration of COD (mg/L)	Notes
1	0.10		12:00 am Sunday (Day 1) is the beginning of the Regulatory Sampling Period and of time interval 1
Additional Sample Taken (Sample 1)	0.20	2500	Apply this concentration to time interval 1
3	0.00		Tuesday 11:59 pm (Day 3) is upper time bound for time interval 1
Permit Required Sample Taken (Sample 2)	0.20	2200	12:00 am Wednesday (Day 4) is lower time bound for interval 2. Apply this concentration to time interval 2.
5	0.20		Thursday 11:59 pm (Day 5) is upper time bound for time interval 2
6	0.20		Friday 12:00 am (Day 6) is lower time bound for time interval 3
Additional Sample Taken (Sample 3)	0.30	1800	11:59 pm Saturday (Day 7) is the end of the Regulatory Sample Period and time interval 3. Apply this concentration to time interval 3.
Total Flow for Month	1.20		

Flow for time interval 1 is 0.30 MG. Interval 1 loading is (2500 mg/L * 0.30 MG * 8.34 lb/MG) / 100 acres = 63 b/acre.

Flow for time interval 2 is 0.40 MG. Interval 2 loading is (2200 mg/L * 0.40 MG * 8.34) lb/MG / 100 acres = 73 lb/acre.

Flow for time interval 3 is 0.50 MG. Interval 3 loading is (1800 mg/L * 0.50 MG * 8.34) lb/MG / 100 acres = 75 lb/acre.

TOTAL Loading for the Week = 211 lb/acre

Or - Arithmetically Average the Sample Concentration Results and Use the Average to Apply to Weekly Flows

[(2500 + 2200 + 1800) / 3] mg/L * 1.20 MG * 8.34 lb/MG / 100 acres = 217 lb/acre

4.4.13.1.4 Example #4:

One Required Sample for the Regulatory Sample Period (Month) Plus Three Additional Samples. Month of November. HMU MU-0999-01 (100 acres)

Table 4-18. Data for Example 2.

Wastewater Sample Date and Time	Daily Flows (MG)	Sample Concentration of COD (mg/L)	Notes
1	0.10		12:00 am November 1st is the beginning of the Regulatory Sampling Period and of time interval 1
2	0.20		
3	0.50		
4	0.30		
5	0.60		
6	0.40		
7	0.30		
Additional Sample Taken (Sample 1)	0.30	2500	
9	0.00		
10	0.20		
11	0.20		
12	0.10		
13	0.30		
Permit Required Sample Taken (Sample 2)	0.20	2200	
15	0.20		
16	0.10		
17	0.10		
18	0.20		
19	0.30		
20	0.60		
Additional Sample Taken (Sample 3)	0.30	1800	
22	0.10		
23	0.10		
24	0.00		
25	0.30		
Additional Sample Taken (Sample 4)	0.40	2000	
27	0.40		
28	0.20		
29	0.10		
30	0.10		11:59 pm November 30th is the end of the Regulatory Sample Period and time interval 4
31	-		
Total Flow for Month	7.20		

[(2500*0.3 + 2200*0.2 + 1800*0.3 + 2000*0.4) /(0.3 + 0.2 + 0.3 + 0.4] mg/L * 7.20 MG * 8.34 lb/MG / 100 acres = TOTAL Loading for the Month = 1266 lb/acre

4.4.13.2 Significant Figures

The following discussion of significant figures comes from 'Uncertainties and Error Propagation: Part I of a manual on Uncertainties, Graphing, and the Vernier Caliper', by Vern Lindberg, Copyright July 1, 2000, and is used with permission:

The rules for propagation of errors hold true for cases when we are in the lab, but doing propagation of errors is time consuming. The rules for significant figures allow a much quicker method to get results that are approximately correct even when we have no uncertainty values.

A significant figure is any digit 1 to 9 and any zero which is not a place holder. Thus, in 1.350 there are 4 significant figures since the zero is not needed to make sense of the number. In a number like 0.00320 there are 3 significant figures—the first three zeros are just place holders. However the number 1350 is ambiguous. You cannot tell if there are 3 significant figures—the 0 is only used to hold the units place—or if there are 4 significant figures and the zero in the units place was actually measured to be zero.

How do we resolve ambiguities that arise with zeros when we need to use zero as a place holder as well as a significant figure? Suppose we measure a length to three significant figures as 8000 cm. Written this way, we cannot tell if there are 1, 2, 3, or 4 significant figures. To make the number of significant figures apparent we use scientific notation, 8×10^3 cm (which has one significant figure), or 8.00 x 103 cm (which has three significant figures), or whatever is correct under the circumstances.

We start then with numbers each with their own number of significant figures and compute a new quantity. How many significant figures should be in the final answer? In doing running computations we maintain numbers to many figures, but we must report the answer only to the proper number of significant figures.

In the case of addition and subtraction we can best explain with an example. Suppose one object is measured to have a mass of 9.9 gm and a second object is measured on a different balance to have a mass of 0.3163 gm. What is the total mass? We write the numbers with question marks at places where we lack information. Thus 9.9???? gm and 0.3163? gm. Adding them with the decimal points lined up we see

09.9????
00.3163?
10.2???? = 10.2 gm.

In the case of multiplication or division we can use the same idea of unknown digits. Thus the product of 3.413? and 2.3? can be written in long hand as

3.413?
2.3?
  ?????
 10239?
 6826?
7.8????? = 7.8

The short rule for multiplication and division is that the answer will contain a number of significant figures equal to the number of significant figures in the entering number having the least number of significant figures. In the above, Example 2.3 had 2 significant figures while 3.413 had 4, so the answer is given to 2 significant figures.

It is important to keep these concepts in mind as you use calculators with 8 or 10 digit displays if you are to avoid mistakes in your answers and to avoid the wrath of physics instructors everywhere. A good procedure to use is to use all digits (significant or not) throughout calculations, and only round off the answers to appropriate "sig fig."

4.4.14 Determining Nitrogen Loading Limit Compliance

Wastewater Reuse permits typically include limits on the amount of nitrogen that can be applied to the land treatment site. These limits vary according to the treatment capacity of the site and other site-specific factors. Common limits that appear in permits include a) 150% of typical crop uptake based on site records; 150% of uptake values from standard tables; application rates as advised in University of Idaho Fertility Guides; or other site-specific limit.

For example, in order to determine compliance with 150% of typical crop uptake limit, take the following steps:

Calculate the annual nitrogen uptake (in pounds per acre) by the crop or crops harvested from each hydraulic management unit on the site for the three most recent years of plant tissue data. Select the median value from these data and multiply by 1.5. This is the loading limit. (in pounds per acre)

To determine the permit limit for nitrogen using standard tables, find the crop type in Section 7.7.9.1 and look up the nitrogen content. Then multiply by crop yield (per acre) and by 1.5. This is the loading limit based on a standard table. If the crop grown at the site is not included in Section 7.7.9.1, contact DEQ to get nutrient uptake for the crop being grown.

Note that the permit limit may change from year to year as the crop type changes or the crop yield changes.

Calculate the annual amount of nutrients applied (in pounds per acre) by wastewater application or from other sources, such as supplemental fertilizers in pounds per acre. For further information on how to make this calculation, see Section 4.2.1.1.

Compare the permit limit calculated in Step 1 above to the amount of nitrogen applied calculated in Step 2 to determine compliance.

4.4.14.1 Example Calculations

4.4.14.1.1 Example 1

Crop type:	Alfalfa Hay
Crop yield:	4.5 tons/acre
Wastewater applied to land treatment field:	6 million gallons per year
Land application area:	20 acres
Wastewater total nitrogen:	20 mg/l (ppm)

No supplemental fertilizer applied	

Calculate crop uptake of nitrogen

For alfalfa hay, the nitrogen uptake (from Table 7-30 of Section 7.7.9.1) is 50.4 pounds per ton of yield.

Nitrogen uptake: 4.5 tons/acre x 50.4 pounds N/ton = 226.8 pounds/acre

Calculate the annual nitrogen permit limits (150% of crop uptake)

Nitrogen application permit limit: 226.8 x 1.5 = 340 pounds/acre

(round off to nearest whole number)

Calculate the annual amount of nitrogen applied with the wastewater

$$6\,\frac{\text{MG}}{\text{year}} * 20\,\frac{\text{mg}}{\text{L}}\text{N} * 8.34\,\frac{\frac{\text{lb}}{\text{MG}}}{\frac{\text{mg}}{\text{L}}} * \frac{1}{20\text{ acres}} = 50.0\,\frac{\text{lbs}}{\text{acre}}$$

Compare the annual nitrogen applied versus the annual permit limit to determine compliance.

	Permit Limit 150% of crop uptake	Amount applied	In compliance with permit limit?
Nitrogen	340 pounds/acre	50 pounds/acre	Yes

4.4.14.1.2 Example 2

Crop type:	Forest Site (pine tree)
Crop yield:	Harvest according to silvicultural plan
Wastewater applied to land treatment field:	14 million gallons per year
Land application area:	26 acres
Wastewater total nitrogen:	15 mg/l (ppm)
No supplemental fertilizer applied	

Calculate the annual crop uptake of nitrogen

From Table 7-30, Section 7.7.9.1, for tree sites, the nitrogen uptake allowance is up to 220 pounds per acre.

Calculate the annual nitrogen permit limits (150% of crop uptake)

Nitrogen application permit limit: 220 x 1.5 = 330 pounds/acre

(round off to nearest whole number)

Calculate the annual amount of nitrogen applied with the wastewater

$$14\,\frac{MG}{year} * 15\,\frac{mg}{L}N * 8.34\,\frac{\frac{lb}{MG}}{\frac{mg}{L}} * \frac{1}{26\,acres} = 67.4\,\frac{lbs}{acre}$$

Compare the annual nitrogen applied versus the annual permit limit to determine compliance

	Permit Limit 150% of crop uptake	Amount applied	In compliance with permit limit?
Nitrogen	330 pounds/acre	67.4 pounds/acre	Yes

4.4.15 Quantifying Soil COD Assimilative Capacity

Carlisle and Phillips (1976) proposed a methodology for quantifying soil assimilative capacity for organic waste applied to land. This methodology is based upon the rate of oxygen to diffuse into a soil to satisfy the oxygen demand imposed upon the soil system by addition of organic waste. This methodology assumes that soil microorganisms will mediate the reaction between oxygen and oxygen demand and will not be limiting. This assumption may not hold true when soil temperatures are low and soil microorganisms are metabolizing at lower rates. The methodology involves quantifying oxygen diffusion into the soil, determining oxygen demand imposed on the soil from waste, and accounting for irrigation frequency and drainage times in the calculation of assimilation capacity.

4.4.15.1 Oxygen Diffusion into the Soil

The following equations are used to determine oxygen diffusion into the soil. Equation 4-23 calculates the effective diffusion coefficient through the soil mass

$$D_p = 0.6 * S * D_o$$

Equation 4-23. Calculation of the effective diffusion coefficient through soil.

Where:

D_p = effective diffusion coefficient through the soil mass (cm^2/sec or m^2/day)

D_o = diffusion coefficient in air (cm^2/sec or m^2/day)

S = air filled porosity of soil (at field capacity), as per Equation 4-24:

$$S = P_t - \Theta_{FC} = \left[1 - \frac{D_B}{D_p}\right] - \Theta_{FC}$$

Equation 4-24. Calculation of air-filled porosity of soil.

Where

P_t = total soil pore space

D_B = soil bulk density (see Table 4-19 for general values)

D_p = particle density (generally assume 2.65 g/cm^3 for most soils)

Θ_{FC} = soil water content at field capacity (see Table 4-19 for general values)

Table 4-19. Generalized Soil Porosity Data.

USDA Soil Texture	(I) Saturated Water Content (total porosity) Θs cm3/cm3	(II) Residual Water Content (wilting point) Θr cm3/cm3	(III) Field Capacity Water Content (1/3 bar) Θfc cm3/cm3	(IV) Air-Filled Porosity at Field Capacity cm3/cm3	(V) Water Filled Porosity Θw cm3/cm3	(VI) Dry Bulk Density Db g/cm3
Clay	0.459	0.098	0.332	0.127	0.215	1.43
Clay loam	0.442	0.079	0.257	0.185	0.168	1.48
Loam	0.399	0.061	0.235	0.164	0.148	1.59
Loamy sand	0.39	0.049	0.103	0.287	0.076	1.62
Silt	0.489	0.05	0.284	0.205	0.167	1.35
Silt loam	0.439	0.065	0.295	0.144	0.18	1.49
Silty clay	0.481	0.111	0.321	0.16	0.216	1.38
Silty clay loam	0.482	0.09	0.306	0.176	0.198	1.63
Sand	0.375	0.053	0.055	0.32	0.054	1.66
Sandy clay	0.385	0.117	0.277	0.108	0.197	1.63
Sandy clay loam	0.384	0.063	0.229	0.155	0.146	1.63
Sandy loam	0.387	0.039	0.167	0.22	0.103	1.62

From Environmental Quality Management, Inc. (June 19, 2003)
(I), (II), and (V) from Table 10
(III) from Table 10 = 2*(V) - (II)
(IV) = (I) - (III)
(VI) from Table 4

Equation 4-25 uses the effective diffusion coefficient to calculate oxygen moving into the soil.

$$M = 2(C_o - C_p)\sqrt{D_p T / \pi}$$

Equation 4-25. Calculation of oxygen movement into the soil.

Where:

M = O_2 moving into soil (g/m^2)

C_o = concentration of O_2 in air above ground (mg/L or g/m^3).

C_p = concentration of O_2 in soil air (mg/L or g/m^3)

D_p = effective diffusion coefficient through the soil mass (or oxygen diffusivity for soil) in m^2/day)

T = time (days)

Working the example from Carlisle and Phillips (1976), we are given an S for a Norwalk sandy loam of S = 0.22 and D_o = 1.62 m^2/day to obtain the result of Equation 4-26.

$$D_p = 0.6 * 0.22 * 1.62 = 0.214 \;\; m^2 / day$$

Equation 4-26. Example calculation of D_p.

Calculating oxygen moving into the soil, we are given the following:

C_o = assume 21 percent O_2 in air above ground, or 300 g/m^3.

C_p = need a concentration of O_2 in soil air greater than 10 percent to prevent root death, so set the boundary condition here to be 143 g/m^3.

D_p = 0.214 m^2/day as previously calculated.

T = 1 day to calculate on a 'per day' basis.

So we have Equation 4-27.

$$M = 2(300 - 143)\sqrt{0.214(1)/\pi} = 82 \;\; g/m^2/day = 730 \;\; lb/acre/day$$

Equation 4-27. Example calculation of M.

Of this calculated 730 lb/acre/day of oxygen diffusing into the soil, respiration of plant roots and microorganisms closely associated with root surfaces require oxygen. Carlisle and Phillips (1979) assume this oxygen use to range from 4 to 6 lbs/acre/hour, or 96 to 144 lb/acre/day. To calculate the amount of oxygen available to oxidize organic waste (O_w), root/microorganism oxygen use (O_r) must be subtracted from the total oxygen entering the soil, as in Equation 4-28.

$$O_w = M - O_r = 732 - 144 = 588 \;\; lb/acre/day$$

Equation 4-28. Calculation of oxygen available for oxidizing organic waste.

4.4.15.2 Irrigation Scheduling and Calculating Assimilative Capacity

Irrigation events inhibit oxygen diffusion into the soil. Soils must drain to field capacity before oxygen diffusion will take place at rates calculated above. Soil drainage times must be accounted for when calculating assimilative capacity over time, as in Equation 4-29.

$$C_a = [(G_t - I_n D_t)/G_t](O_w)$$

Equation 4-29. Calculation of soil assimilative capacity.

Where:
C_a = soil assimilative capacity (lb/acre/day)

G_t = length of the growing season (days)

I_n = number of irrigation events in the growing season

D_t = soil drainage time to field capacity (days) (see Table 7-26, Section 7.7.7)

O_w = oxygen available to oxidize organic waste (lb/acre/day)

For example, given:

G_t = 214 days

I_n = 30 irrigation events

D_t = 3 days

O_w = 588 lb/acre/day

$$C_a = [(214 - (30)(3)/214](588) = 340 \ lb/acre/day$$

4.4.15.3 Determining Oxygen Demand Imposed on the Soil from Wastewater

Oxygen demand of wastewater is determined by chemical analysis. Total oxygen demand (TOD) consists of the sum of chemical oxygen demand (COD) and nitrogenous oxygen demand (NOD) as Equation 4-30 relates:

$$\mathrm{TOD} = \mathrm{COD} + \mathrm{NOD}$$

Equation 4-30. Calculation of total oxygen demand (TOD).

The value for COD is obtained through chemical analysis. BOD is sometimes used in lieu of COD. NOD represents the oxygen required to oxidize the reduced nitrogen forms ammonia and organic nitrogen. Total Kjeldahl nitrogen (TKN) is the chemical analysis used to quantify reduced nitrogen species. To convert TKN nitrogen (mg/L) to NOD, it must be multiplied by 4.56 because it takes approximately two moles (or 2 mmol) of O_2 to oxidize one mole (or 1 mmol) of TKN to NO_3, as Equation 4-31 relates:

$$1\,\mathrm{mg\ N/L} \cdot \left[\frac{2\,\mathrm{mmol\,O_2}}{1\,\mathrm{mmol\,N}}\right] \cdot \left[\frac{32\,\mathrm{mg\,O_2} / \mathrm{mmol\,O_2}}{14\,\mathrm{mg\,N} / \mathrm{mmol\,N}}\right] = \frac{64\,\mathrm{mg\,O_2}}{14\,\mathrm{mg\,N}} = 4.56\,\mathrm{mg\,O_2}$$

Equation 4-31. Calculation of oxygen demand.

So the equation for total oxygen demand becomes as shown in Equation 4-32.

$$TOD = COD + 4.56 \ TKN$$

Equation 4-32. Total oxygen demand as a function of COD and TKN.

TOD in mg/L is used along with wastewater volume and acreage in loading calculations as described in Section 4.2.1.1 to determine the oxygen demand imposed on the soil from wastewater.

4.4.16 Metal and other Trace Element Loading [40CFR 503.13]

[Code of Federal Regulations]
[Title 40, Volume 28]
[Revised as of July 1, 2004]
From the U.S. Government Printing Office via GPO Access
[CITE: **40CFR503.13**]
[Page 826-827]

TITLE 40--PROTECTION OF ENVIRONMENT

CHAPTER I--ENVIRONMENTAL PROTECTION AGENCY (CONTINUED)

PART 503_STANDARDS FOR THE USE OR DISPOSAL OF SEWAGE SLUDGE
--Table of Contents

Subpart B_Land Application

Sec. 503.**13** Pollutant limits.

(a) Sewage sludge. (1) Bulk sewage sludge or sewage sludge sold or given away in a bag or other container shall not be applied to the land if the concentration of any pollutant in the sewage sludge exceeds the ceiling concentration for the pollutant in Table 1 of Sec. 503.**13**.

(2) If bulk sewage sludge is applied to agricultural land, forest, a public contact site, or a reclamation site, either:

(i) The cumulative loading rate for each pollutant shall not exceed the cumulative pollutant loading rate for the pollutant in Table 2 of Sec. 503.**13**; or

(ii) The concentration of each pollutant in the sewage sludge shall not exceed the concentration for the pollutant in Table 3 of Sec. 503.**13**.

(3) If bulk sewage sludge is applied to a lawn or a home garden, the concentration of each pollutant in the sewage sludge shall not exceed the concentration for the pollutant in Table 3 of Sec. 503.**13**.

(4) If sewage sludge is sold or given away in a bag or other container for application to the land, either:

[[Page 827]]

(i) The concentration of each pollutant in the sewage sludge shall not exceed the concentration for the pollutant in Table 3 of Sec. 503.**13**; or

(ii) The product of the concentration of each pollutant in the sewage sludge and the annual whole sludge application rate for the sewage sludge shall not cause the annual pollutant loading rate for the pollutant in Table 4 of Sec. 503.**13** to be exceeded. The procedure used to determine the annual whole sludge application rate is presented in appendix A of this part.

(b) Pollutant concentrations and loading rates--sewage sludge.--(1) Ceiling concentrations.

Table 1 of Sec. 503.**13**--Ceiling Concentrations

Pollutant	Ceiling concentration (milligrams per kilogram) \1\

Arsenic	75
Cadmium	85
Copper	4300
Lead	840
Mercury	57
Molybdenum	75
Nickel	420
Selenium	100
Zinc	7500

\1\ Dry weight basis.

(2) Cumulative pollutant loading rates.

Table 2 of Sec. 503.**13**--Cumulative Pollutant Loading Rates

Pollutant	Cumulative pollutant loading rate (kilograms per hectare)
Arsenic	41
Cadmium	39
Copper	1500
Lead	300
Mercury	17
Nickel	420
Selenium	100
Zinc	2800

(3) Pollutant concentrations.

Table 3 of Sec. 503.**13**--Pollutant Concentrations

Pollutant	Monthly average concentration (milligrams per kilogram) \1\
Arsenic	41
Cadmium	39
Copper	1500
Lead	300
Mercury	17
Nickel	420
Selenium	100
Zinc	2800

\1\ Dry weight basis.

(4) Annual pollutant loading rates.

Table 4 of Sec. 503.**13**--Annual Pollutant Loading Rates

Pollutant	Annual pollutant loading rate (kilograms per hectare

	per 365 day period)
Arsenic	2.0
Cadmium	1.9
Copper	75
Lead	15
Mercury	0.85
Nickel	21
Selenium	5.0
Zinc	140

(c) Domestic septage. The annual application rate for domestic septage applied to agricultural land, forest, or a reclamation site shall not exceed the annual application rate calculated using equation (1).

[GRAPHIC] [TIFF OMITTED] TC15NO91.192

Where:

AAR=Annual application rate in gallons per acre per 365 day period.

N=Amount of nitrogen in pounds per acre per 365 day period needed by the crop or vegetation grown on the land.

[58 FR 9387, Feb. 19, 1993, as amended at 58 FR 9099, Feb. 25, 1994; 60 FR 54769, Oct. 25, 1995]

4.4.17 Determining Compliance with Reuse Permit Phosphorus Limits

Wastewater Reuse permits may include limits on the amount of phosphorus that can be applied to the land treatment site. These limits are determined utilizing guidance as previously discussed (for example, 100% of crop uptake).

For example, to determine compliance with a limit of 100 % of typical crop uptake, take the following steps:

Calculate the annual phosphorus uptake by the crop or crops harvested from each hydraulic management unit on the site for the three most recent years of data plant tissue data. Select the median value from these data. This is the loading limit in pounds per acre.

To determine the annual permit limit for phosphorus using standard tables, find the crop type and the phosphorus content. This is the loading limit. based on a standard table. Contact DEQ to get nutrient uptake for the crop being grown or consult the following Idaho Department of Agriculture Web site:

http://www.nass.usda.gov/id/publications/annual%20bulletin/annbulltoc.htm

Note that the permit limit may change from year to year as the crop type changes or the crop yield changes.

Calculate the amount of nutrients applied by wastewater application or from other sources, such as supplemental fertilizers (in pounds per acre). For further information on how to make this calculation, see Section 4.2.1.1.

Compare the annual permit limit calculated in Step 1 above to the amount of phosphorus applied calculated in Step 2 to determine compliance.

4.4.17.1 Example Calculations

4.4.17.1.1 Example 1

Table 20shows and example calculation for crop uptake of phosphorus..

Table 20. Values for example calculation of crop phosphorus uptake.

Crop type	Alfalfa Hay
Crop yield	4.5 tons/acre
Wastewater applied to land treatment field:	6 million gallons per year
Land application area:	20 acres
Wastewater total phosphorus:	5 mg/L (ppm)
No supplemental fertilizer applied	

Calculate the annual crop uptake of phosphorus

For alfalfa hay, assume for this example a phosphorus uptake of 4.72 pounds per ton of yield.

Phosphorus uptake: 4.5 tons/acre x 4.7 pounds P/ton = 21.2 pounds/acre

Calculate the annual phosphorus permit limits (100 % of crop uptake)

Phosphorus application permit limit: 21.2 x 1 = 21.2 pounds/acre

(round off to nearest whole number)

Calculate the annual amount of phosphorus applied with the wastewater

$$6\,\frac{MG}{year} * 5\,\frac{mg}{L}N * 8.34\,\frac{\frac{lb}{MG}}{\frac{mg}{L}} * \frac{1}{20\text{ acres}} = 12.5\,\frac{lbs}{acre}$$

Compare the annual phosphorus applied versus the annual permit limit to determine compliance.

4.4.17.1.2 Example 2

Table 21 shows the data values used for an example calculation of annual phosphorus uptake.

Table 21. Values for example calculation of annual phosphorus uptake.

Crop type:	Forest Site (pine tree)
Crop yield:	Harvest per silvicultural plan
Wastewater applied to land treatment field:	14 million gallons per year
Land application area:	26 acres
Wastewater total phosphorus:	4 mg/L (ppm)
No supplemental fertilizer applied	

Calculate the annual crop uptake of phosphorus

Assume, for tree sites, the phosphorus uptake allowance is 20 pounds per acre.

Calculate the annual phosphorus permit limits (150% of crop uptake)

Phosphorus application permit limit: 20 x 1 = 20 pounds/acre

(round off to nearest whole number)

Calculate the annual amount of phosphorus applied with the wastewater

$$14\,\frac{MG}{year} * 4\,\frac{mg}{L}N * 8.34\,\frac{\frac{lb}{MG}}{\frac{mg}{L}} * \frac{1}{26\text{ acres}} = 18\,\frac{lbs}{acre}$$

Compare annual phosphorus applied versus the annual permit limit to determine compliance

	Permit Limit 100 % of crop uptake	Amount applied	In compliance with permit limit?

Phosphorus	20 pounds/acre	18.0 pounds/acre	Yes

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